

1b

HAVO | VWO

**your biology
TEXTBOOK**

your biology

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BIOLOGIE VOOR TWEETALIG ONDERWIJS
HAVO|VWO ONDERBOUW

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Introduction

This biology book is part 1b of *Your Biology*, an English translation of the popular Dutch textbooks 'Biologie voor jou'. Browsing through the book will show you exactly how it is structured. The way we wrote this book will let you work with it on your own.

You can also ask your teacher for help if you need it.

There is a workbook that belongs with this book, as well as an answer key and the Your Biology website. The website has a digital version of the workbook and/or textbook. There is also the possibility of practising with digital material (including the diagnostic tests).

WORKING WITH YOUR BIOLOGY

The topics in this book are called units. Each unit starts off with an introduction. This gives a brief description of what you can expect in the unit. Each unit is made up of the following sections:

- Basics
- Extra
- Summary
- Diagnostic test
- Extension

We will now describe how to work with each of these sections.

BASICS

The Basics contain texts and figures that you are going to read. You will come across references to the exercises that are in the workbook, for example:

WB EXERCISES 1 AND 2, PAGE 4

You should do the exercises in your workbook.

There is sometimes an optional exercise at the end of the Basics. Your teacher will tell you whether you have to do the optional exercise.

When you have finished the exercises, you will find a reference back to the textbook, for example:

TB BASICS 2, PAGE 10

Sometimes you will have to use the Internet for an exercise.

There are also some exercises that you need a worksheet for. The worksheets are in the workbook. It is useful if you have a pair of scissors and a glue stick. As well as the pens you normally write with, you will need a drawing pencil (HB) and coloured pencils. You can use the answer book to check the exercises yourself.

EXTRA

At the end of the Basics, you will find the Extra section. Once you have finished the Basics, your teacher will tell you whether you have to do the Extra. The completed exercises from the Extra section can be checked with the answer book.

SUMMARY

The summary gives a brief description of what you have learned in the basics and (if you did it) the extra section. This is what you will have to 'know and do' for a test.

DIAGNOSTIC TEST

The diagnostic test lets you see whether you know and can do everything that is in the summary. You can check the diagnostic test using the answer book.

You can also do the diagnostic test via the Your Biology website. You can then see straight away whether your answers are correct.

EXTENSION

If you know and can do everything that is in the summary, you can start on the Extension. This is additional material, with different sections that you can choose between. You do not have to do all the sections; your teacher will tell you how many you have to choose. There are more Extension sections on the Your Biology website.

The exercises in the Extension that are in the workbook can also be checked using the answer book.

We hope that you will enjoy working with this book.

The authors

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5

Support and locomotion



BASICS

- 1 The human skeleton
- 2 The functions of the skeleton
- 3 The structure of bones
- 4 Joints
- 5 Muscles
- 6 Posture and movement
- 7 Injuries

EXTRA

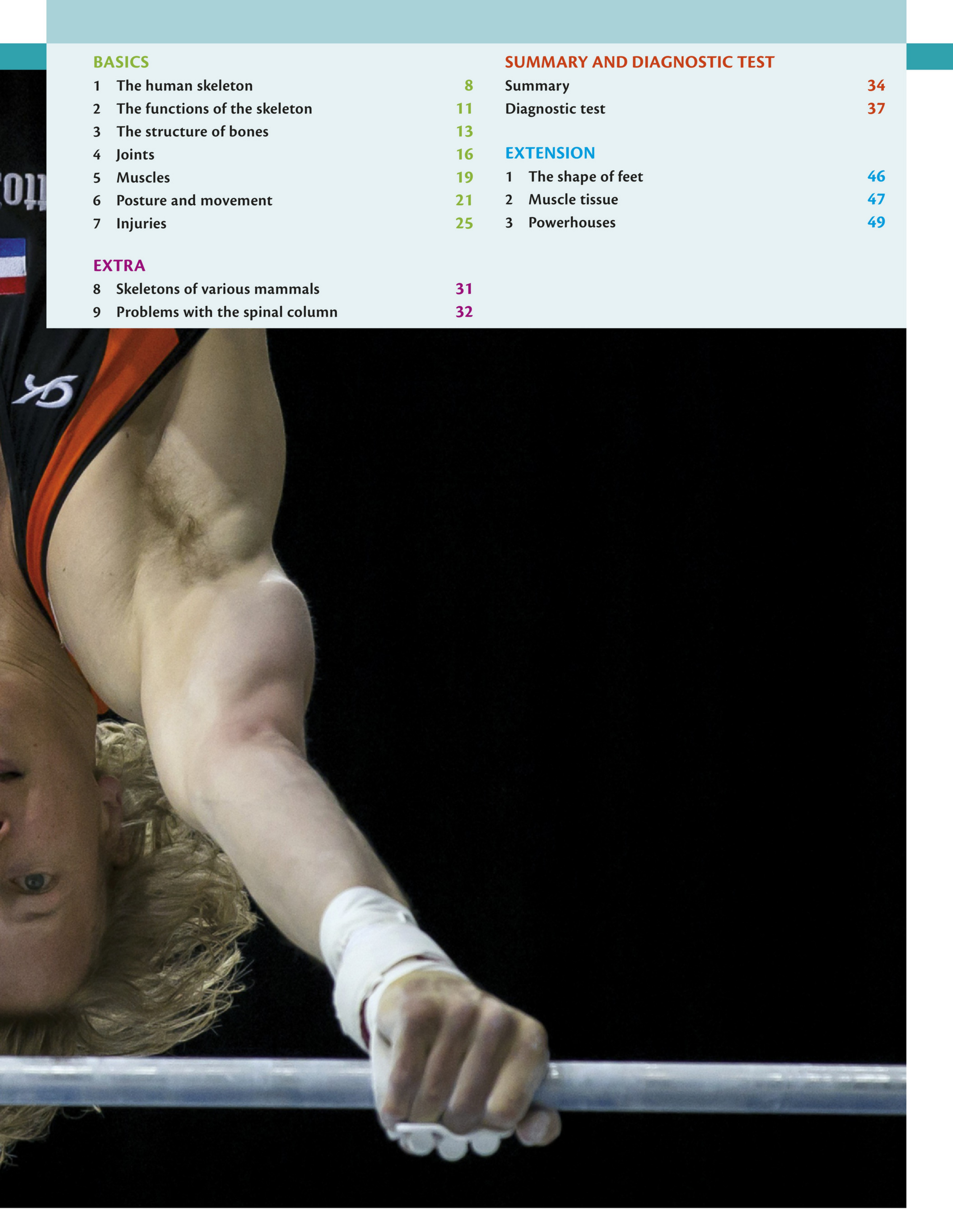
- 8 Skeletons of various mammals
- 9 Problems with the spinal column

SUMMARY AND DIAGNOSTIC TEST

- Summary 34
- Diagnostic test 37

EXTENSION

- 1 The shape of feet 46
- 2 Muscle tissue 47
- 3 Powerhouses 49



This unit is called 'Support and locomotion'. It is about how your body is supported and how you are able to move. First you will learn about the bones that form the human skeleton and what functions the skeleton has. Bones in the skeleton can be connected to each other in various ways. Muscles are attached to the bones. Muscles and joints allow you to make movements. You use your muscles to make sure you have good body posture. You will also learn how injuries can occur and how you can reduce the risk of injury.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 The human skeleton

In Unit 4 (Classification) you learned that humans have an internal **skeleton** with a spinal column. The human skeleton consists of more than two hundred **bones**. In Unit 3 (Organs and cells) you learned that we refer to all these bones together as the human skeletal system.

▼ Fig. 1

A skeleton builder

Mickel van Leeuwen builds skeletons for museums, zoos, schools and educational institutions (see figure 1.1). He is a taxidermist and knows a great deal about skeletal structures. Sometimes he only needs a couple of bones to be able to say what animal it is.

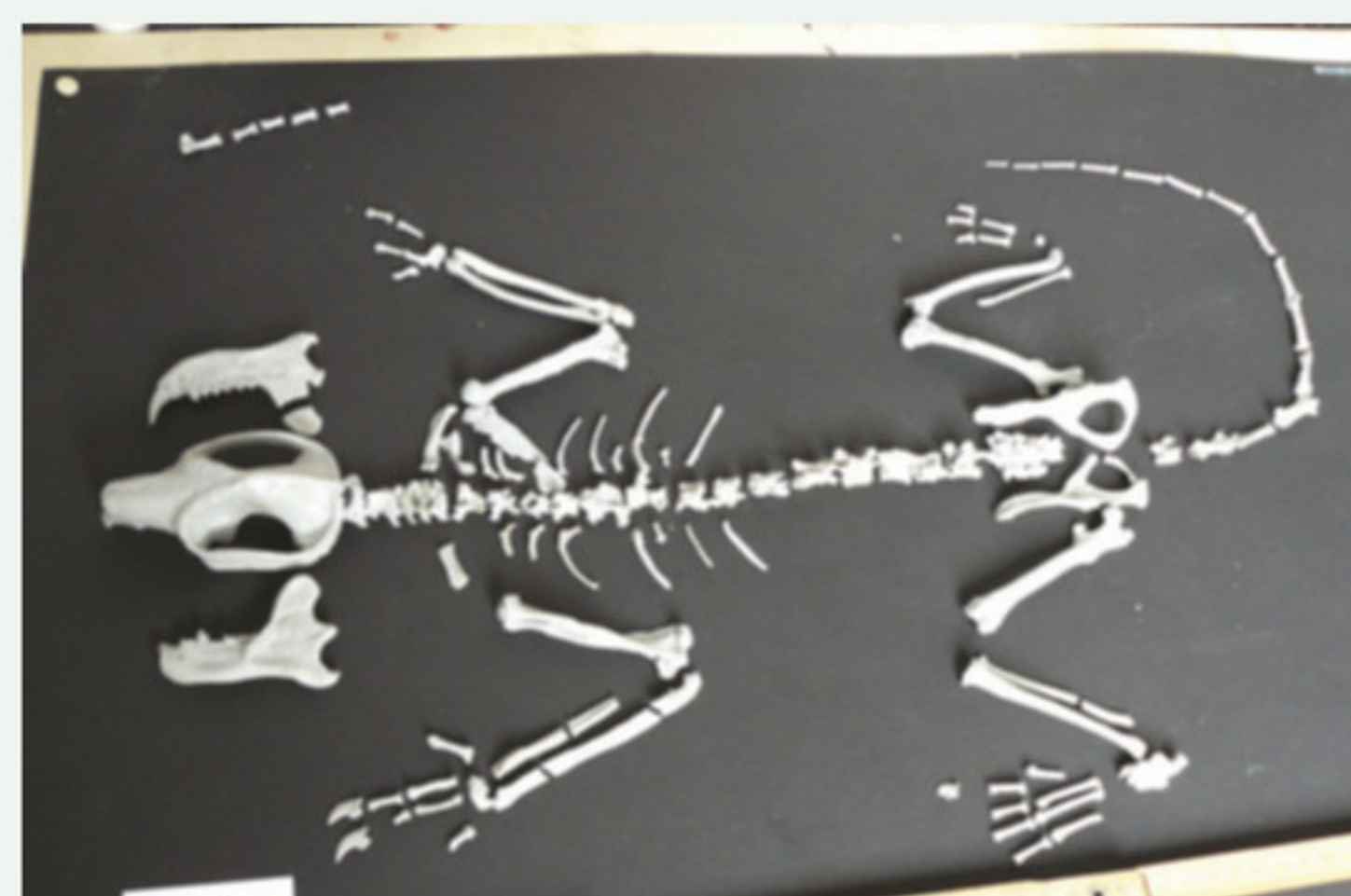
"I often get loose bones, or bones that are all jumbled up. First I clean the bones. Then I find all the vertebrae and lay them out in the correct order. Then I put all the other bones around them in the right places (see figure 1.2). I have a lot of experience and I can recognise the bones quickly from their shapes, so I know where they belong in the skeleton."



1 Mickel van Leeuwen

Mammals have a lot of similar bones, and which animal they come from doesn't make much difference. They all have shoulderblades, for instance. The shape of the shoulderblade varies, but you can still tell that it's a shoulderblade.

"Sometimes a bone may be missing. In that case, I make a replica. Or if a bone is damaged, I will repair it first. Once the skeleton is complete and all the bones have been sorted, I start building the skeleton. I put the loose bones in place with screws and steel wire, but taking care that the metal is not visible. I always try to put the skeleton in an active pose, so that the people looking at the skeletons can get an idea of how the animal lived."

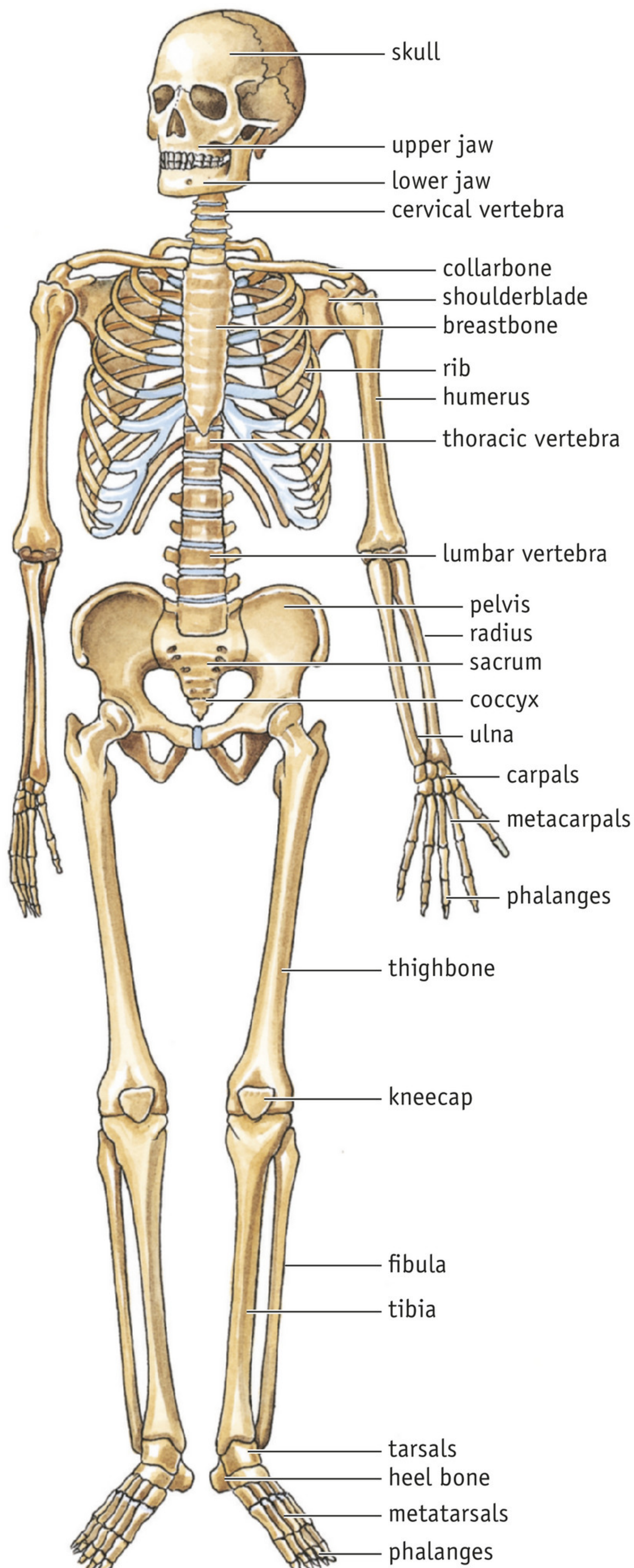


2 sorted bones

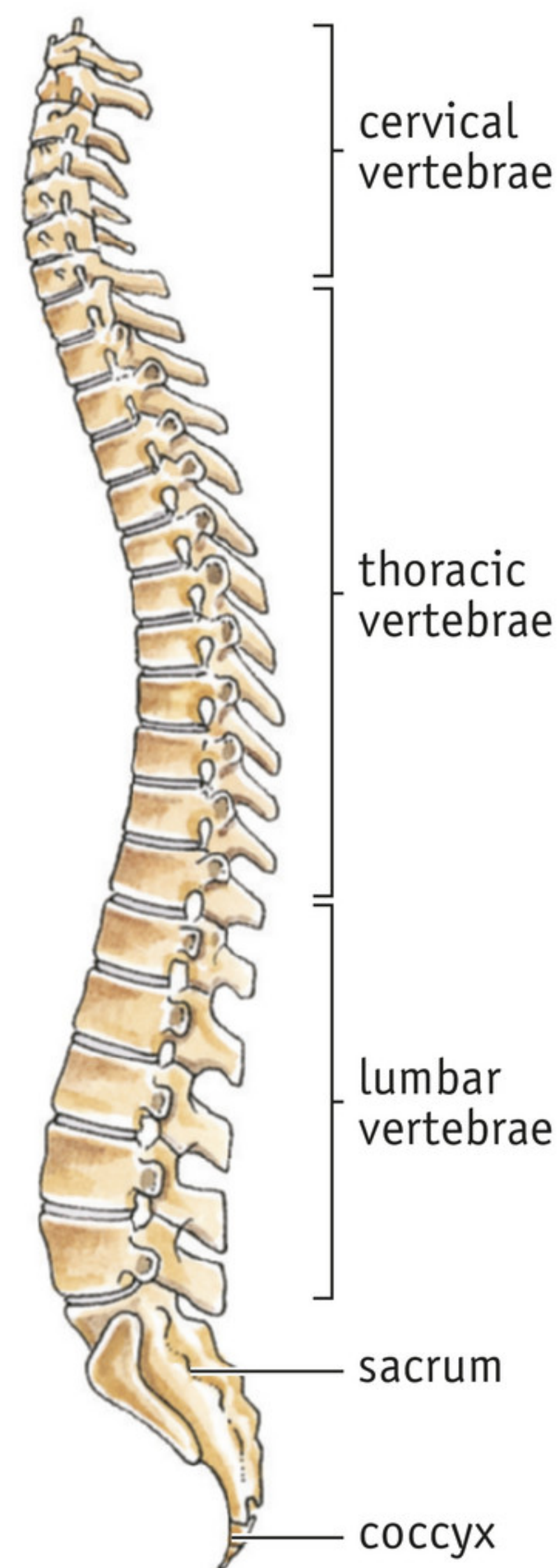
THE STRUCTURE OF THE SKELETON

Figure 2 is a drawing of a human skeleton. The head bones belong to the **skull**. The skull is supported by the **backbone** or spinal column (see figure 3).

▼ Fig. 2 Human skeleton.



▼ Fig. 3 Backbone.



The thoracic vertebrae, the ribs and the breastbone together make up the **ribcage**. The shoulderblades and the collarbones are part of the **pectoral girdle**. The hip bones and the sacrum make up the **pelvis** or **pelvic girdle**. The coccyx is located beneath the sacrum.

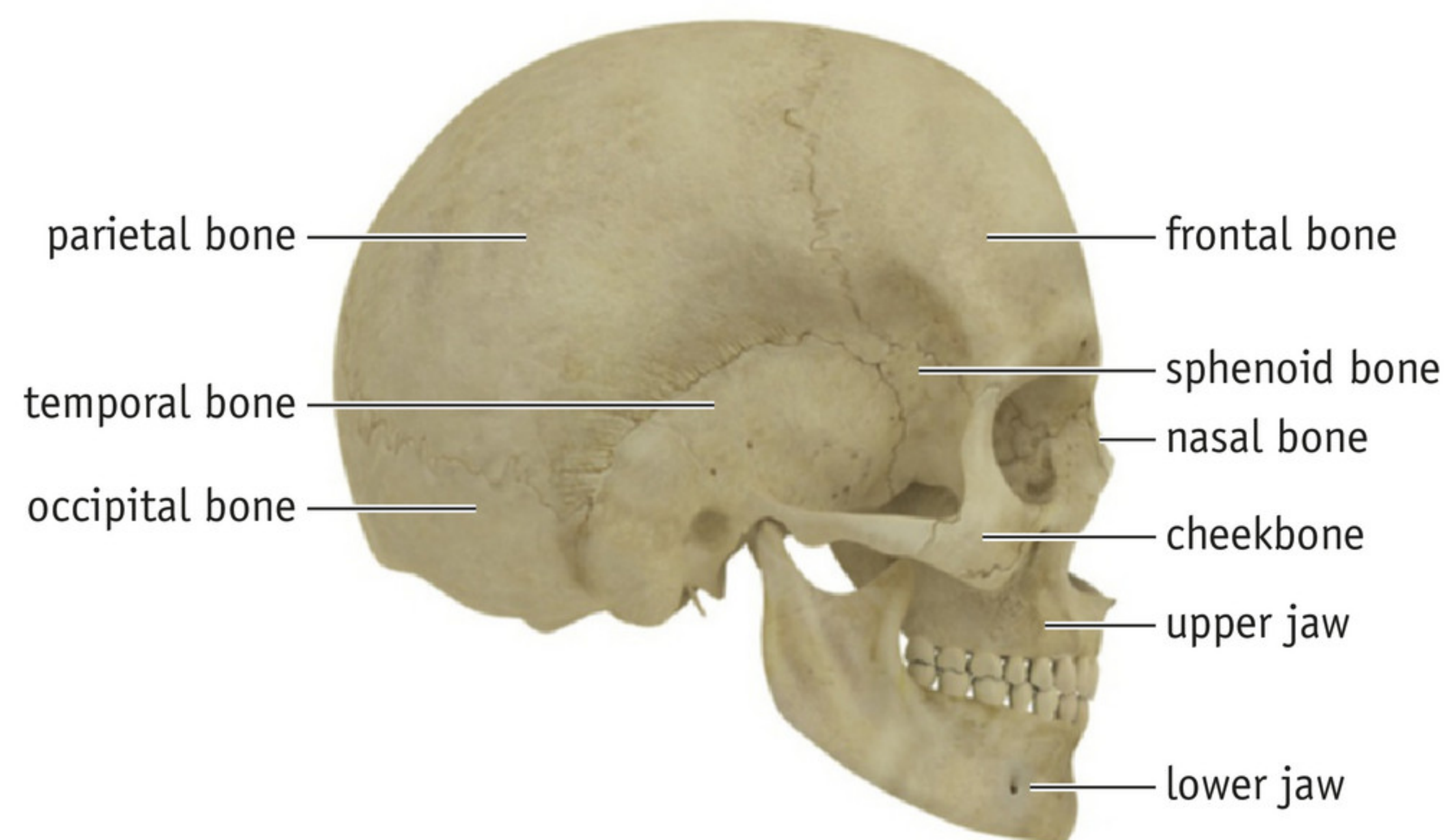
Arms and legs are also referred to as **limbs**. The bones in your arms and legs have a similar structure. An arm consists of the humerus, the ulna, the radius and the hand bones. A leg consists of the thighbone, the tibia, the fibula and the bones of the foot. The radius and the ulna can be difficult to tell apart. It helps to remember that the ulna, the shorter word, is attached to the little finger, the shortest finger.

THE SKULL

Figure 4 shows a human skull seen from the side. The main skull bones are indicated. A skull consists of various bones that are fused together.

WB EXERCISES 1 TO 6, PAGE 6

► Fig. 4 The skull.



2 The functions of the skeleton

▼ Fig. 5

Moped accident

In a collision between a car and a moped on Wednesday evening, a boy aged 13 was severely injured. As a result of the impact, the boy (who was sitting on the back) flew through the air and hit the windscreen of the car. He was not wearing a helmet and was taken to hospital with severe head injuries. The other boy was wearing a helmet and suffered only a few scratches.



Bones are robust and only decay slowly. Because bones are robust, you are able to **stand upright**. The skeleton also makes **movement** possible. Many bones are connected together in a way that lets them move. The muscles attached to these bones make them move.

Your skeleton **protects** a number of organs inside your body. The bony plates of your skull protect your brain, for example, and the ribcage protects your lungs and your heart. That protection is not always enough. Your skull cannot deal with a really hard impact, and your brain can still get damaged. That is why it is sometimes important to wear extra protection, such as a helmet (see figure 5).

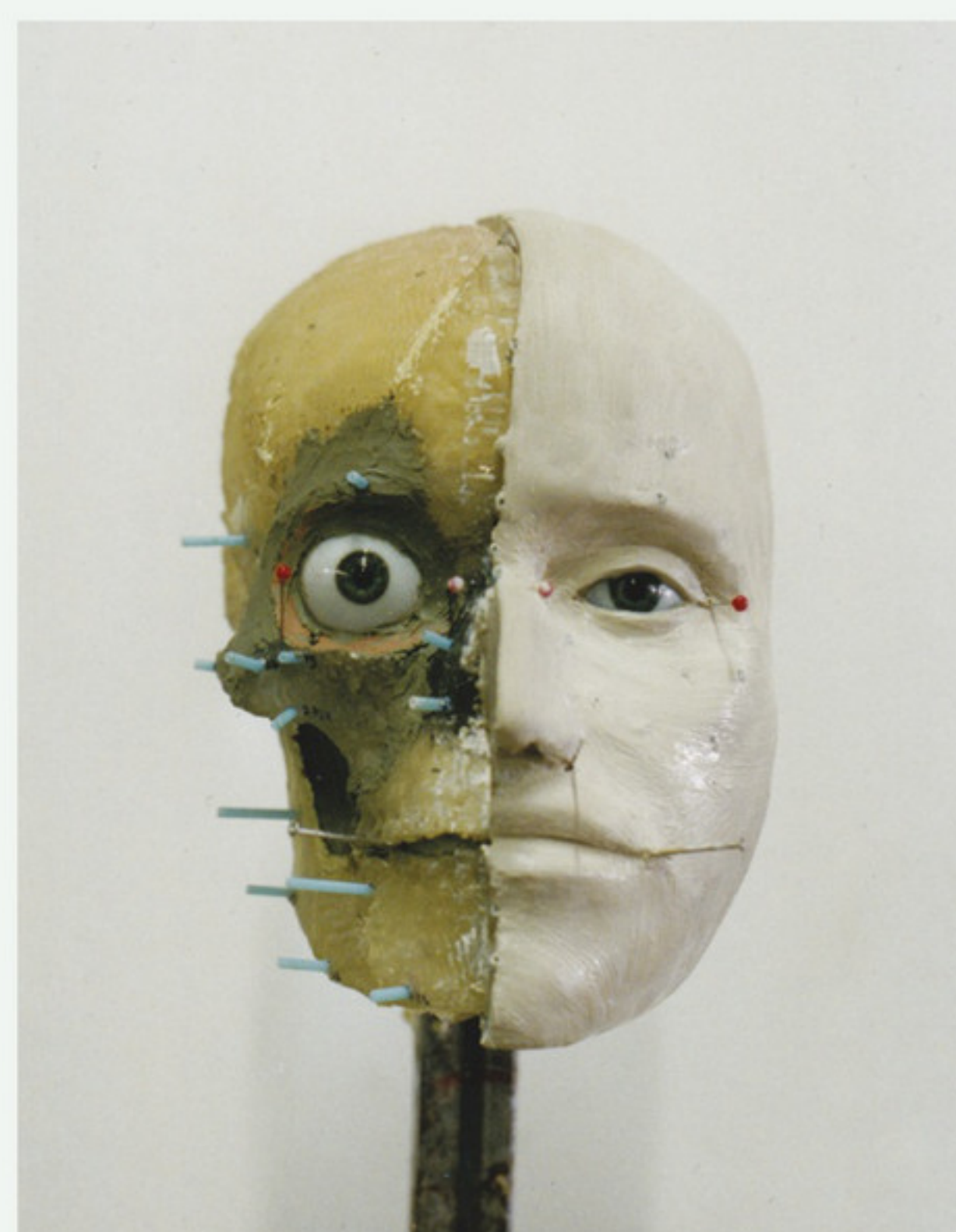
Finally, your skeleton gives your body its **shape**. This means that information from a skeleton can be used for example in a reconstruction to show what someone used to look like (see figure 6). The shape of the skeleton or parts of the skeleton depend on its function.

▼ Fig. 6 Reconstruction of Ypje van Rijswijk.

Ypje van Rijswijk

When a burial ground was excavated in Ypenburg near The Hague, the finds included the skeleton of a young woman. She lived 5500 years ago. A reconstruction was done based on the skull and she was given the name Ypje van Rijswijk (after the former municipality the burial ground was in). The shape of the skull gave information about what the face would have looked like.

First, modern techniques were used to make a model of the skull. The thicknesses of the tissues were then added to the model, taking account of how the muscles are placed. A number of steps were then used to model the face. Finally a cast was made in plastic. It was painted and hair was added.



1 half way through the reconstruction



2 Ypje as she would have looked

▼ **Fig. 7** A dolphin has a streamlined body.



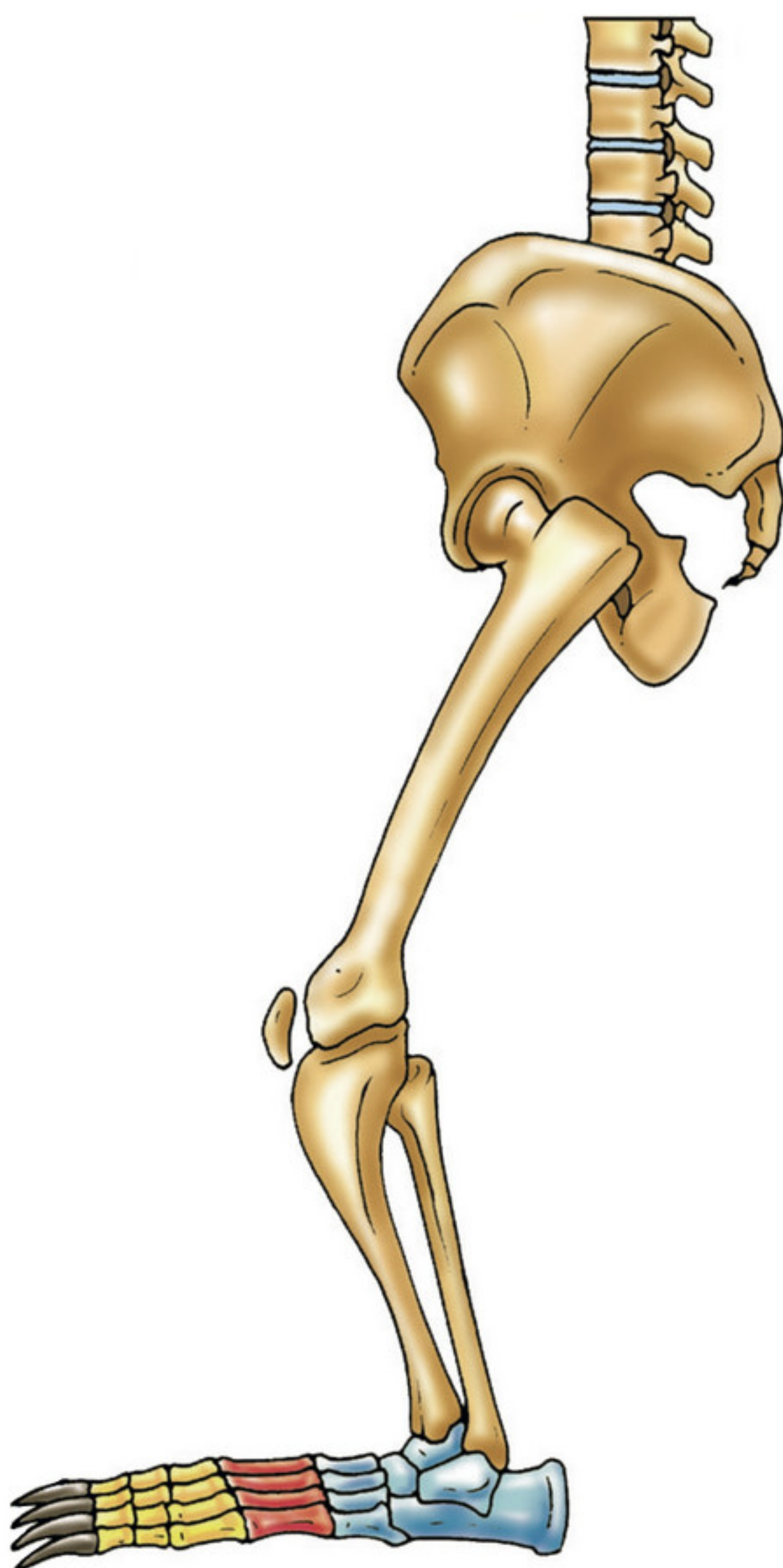
FORM AND FUNCTION

The bones of the skull create a cavity together. This means that the skull can protect the brain. Many bones have protrusions that muscles are attached to. The shape of an organism's body is related to the environment that the organism lives in. A dolphin, for instance, has a **streamlined** body (see figure 7). This allows it to move more quickly through the water. Other animals are streamlined too.

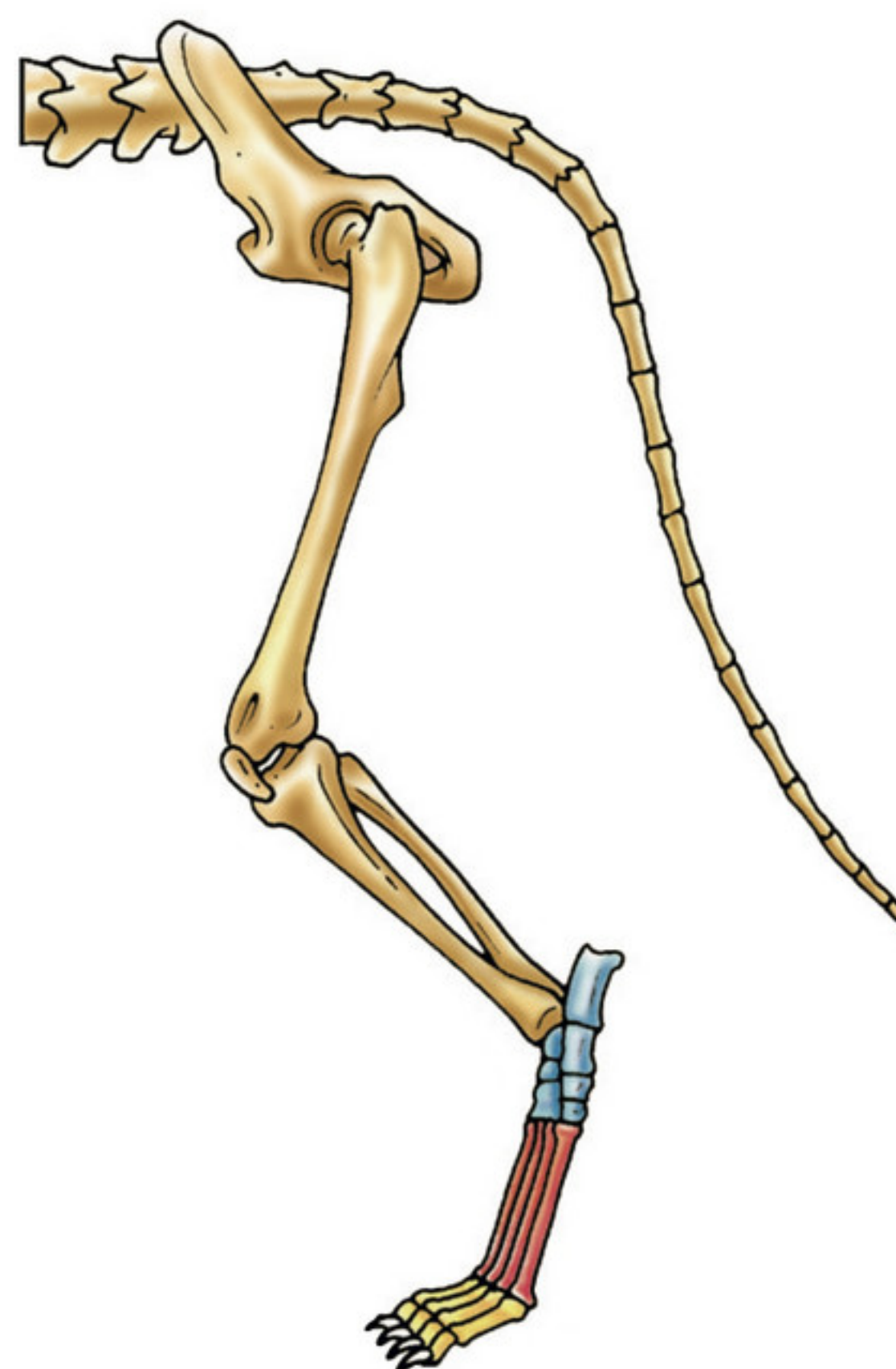
In mammals, the shape of the legs depends on the way that an animal lives. Figure 8 shows the hind legs of a bear, a cat and a horse. You can see that a bear uses the entire sole of the foot as it walks. Animals that walk on the whole sole of the foot are called **plantigrades**. Cats walk on their toes and are called **digitigrades** and horses are **unguligrades**, animals that walk on the tips of their toes. In these animals, the tips of the toes are covered with a hoof. Unguligrades are therefore sometimes also known as **hoofed animals**.

WB EXERCISES 7 TO 9, PAGE 10

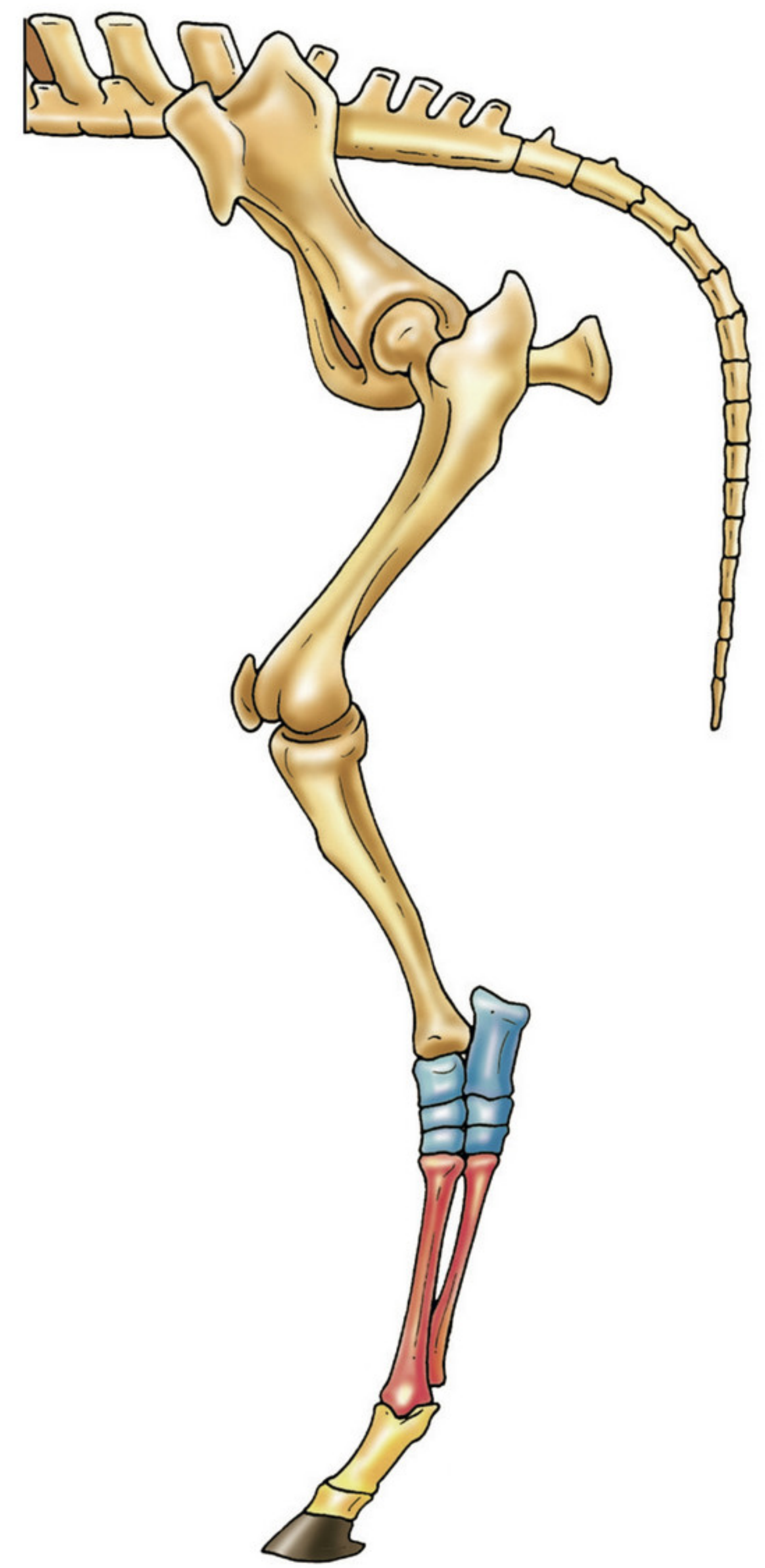
▼ **Fig. 8** Plantigrades, digitigrades and unguligrades.



1 bear (plantigrade)



2 cat (digitigrade)



3 horse (unguligrade or hoofed animal)

3 The structure of bones

Before a taxidermist can start building a skeleton, the bones have to be clean. After cleaning, the bones consist largely of calcium phosphate.

▼ Fig. 9

Cleaning the bones

Mickel van Leeuwen: “Sometimes people bring a dead animal to me. The muscles and other organs are then still inside it. In that case, I remove the organs first and then take the flesh off the bones as far as possible. Then I separate the bones carefully from one another and drill a hole in the long bones, the long and thin ones such as the thighbone and the ulna. I then put the individual bones in a tank of hot water. The bones stay there for a number of weeks. Basically, the skeleton decays in the tank. The hole lets the hot water into the bone and lets the fatty substances get out.”

holes are drilled
in the bones



The skeleton consists of long bones and flat bones. The **long bones** are the long thin ones. Other bones, such as the bony plates of the skull and the pelvic girdle, are called **flat bones**.

BONE AND CARTILAGE

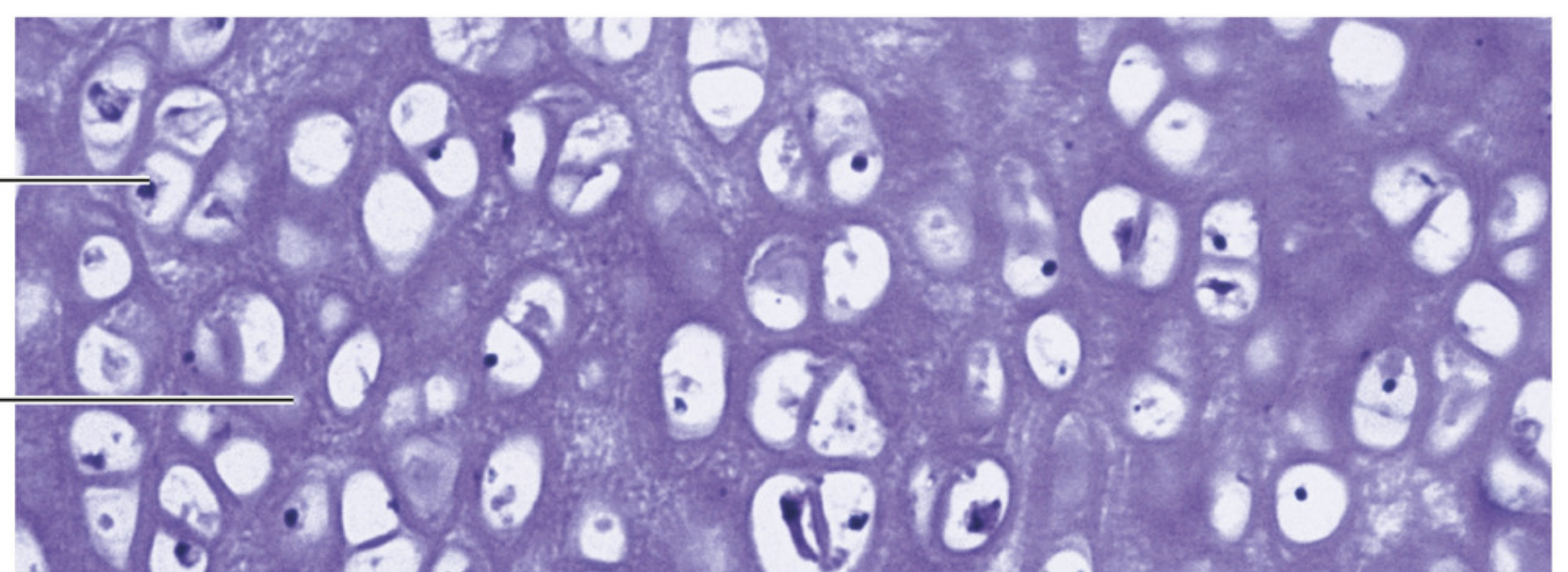
Your body is supported by two different types of tissue: cartilage tissue and bone tissue. Both types of tissue have **extracellular material** between the cells.

Cartilage tissue is composed of cells that are clustered together in the extracellular material (see figure 10). The extracellular material is constructed in such a way that cartilage is strong and flexible.

▼ Fig. 10 Cartilage tissue.

cartilage cell

extracellular
material



▼ Fig. 11



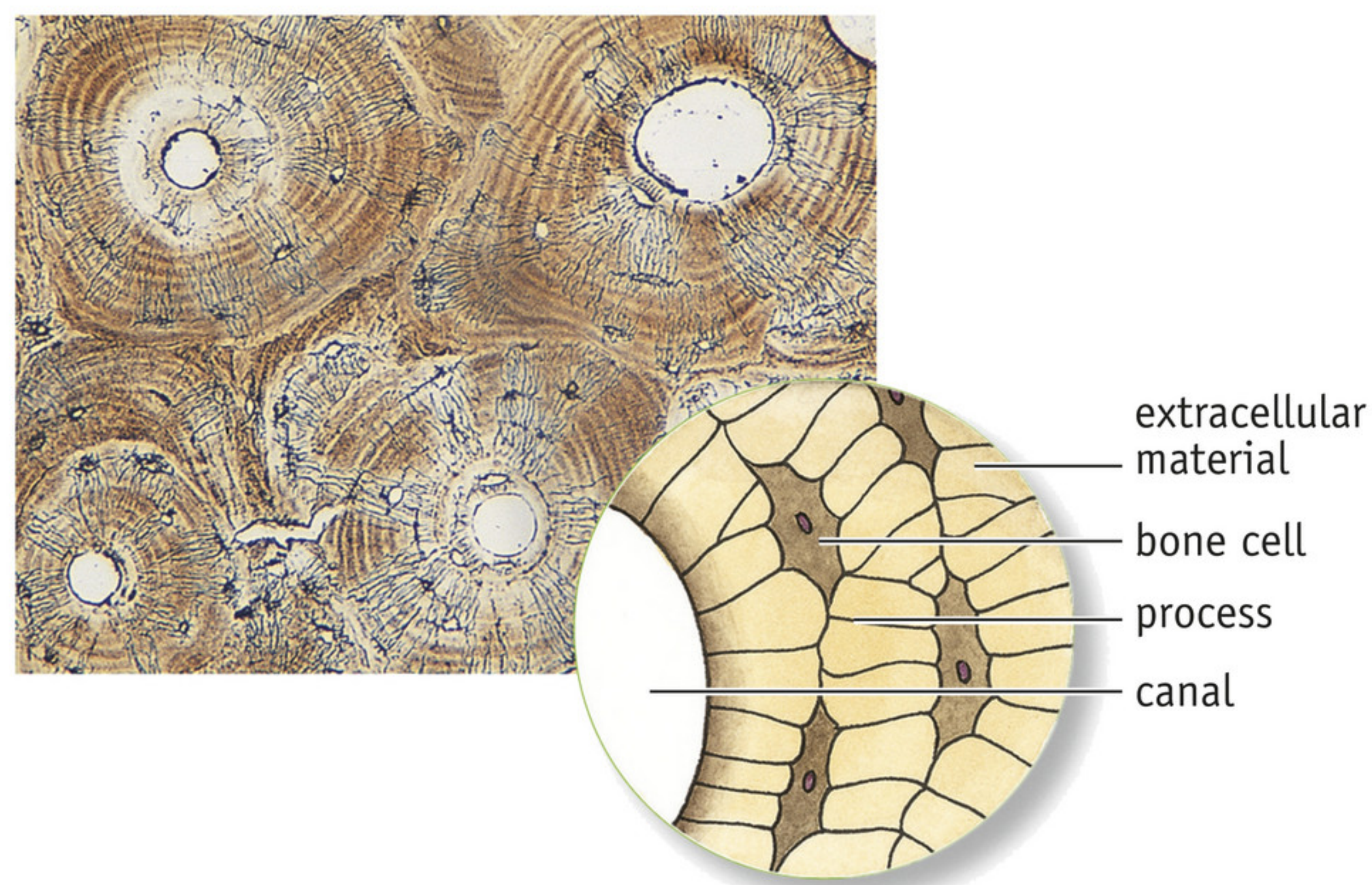
In adults, cartilage occurs at places in the body that are firm but nevertheless flexible, for example in the nose and the ears.

Figure 2 also shows you other parts of the skeleton that are made up of cartilage; these parts are coloured blue.

The skeleton of a baby consists mostly of cartilage tissue. This is why they can easily put their toes into their mouth (see figure 11). As they grow, much of the cartilage is replaced by bone tissue.

Bone tissue is composed of cells surrounding tiny channels or canals (see figure 12). These canals contain blood vessels. The extracellular material in bone tissue is tougher than the extracellular material of cartilage. The extracellular material in bone consists largely of calcium phosphate and collagen.

▼ Fig. 12 Bone tissue.

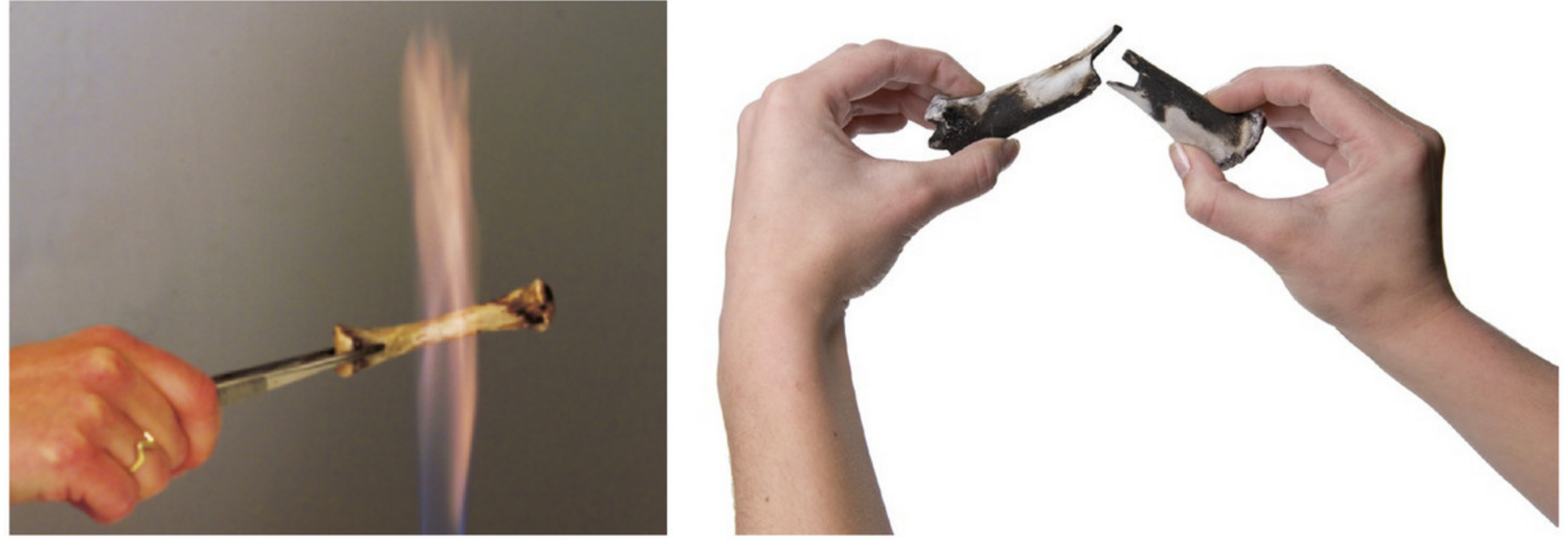


Calcium phosphate makes bones strong and rigid. **Collagen** allows bone tissue to stay a little flexible. These two materials make bone tough and you cannot easily bend or break it. If you leave a bone for a while in a dilute hydrochloric acid solution, the calcium phosphate dissolves from the bone. This makes the bone very flexible (see figure 13). If you hold a bone in a flame, the collagen burns away. The bone can then easily be broken (see figure 14).

► Fig. 13 Bones in dilute hydrochloric acid.



► **Fig. 14** A bone in a flame.

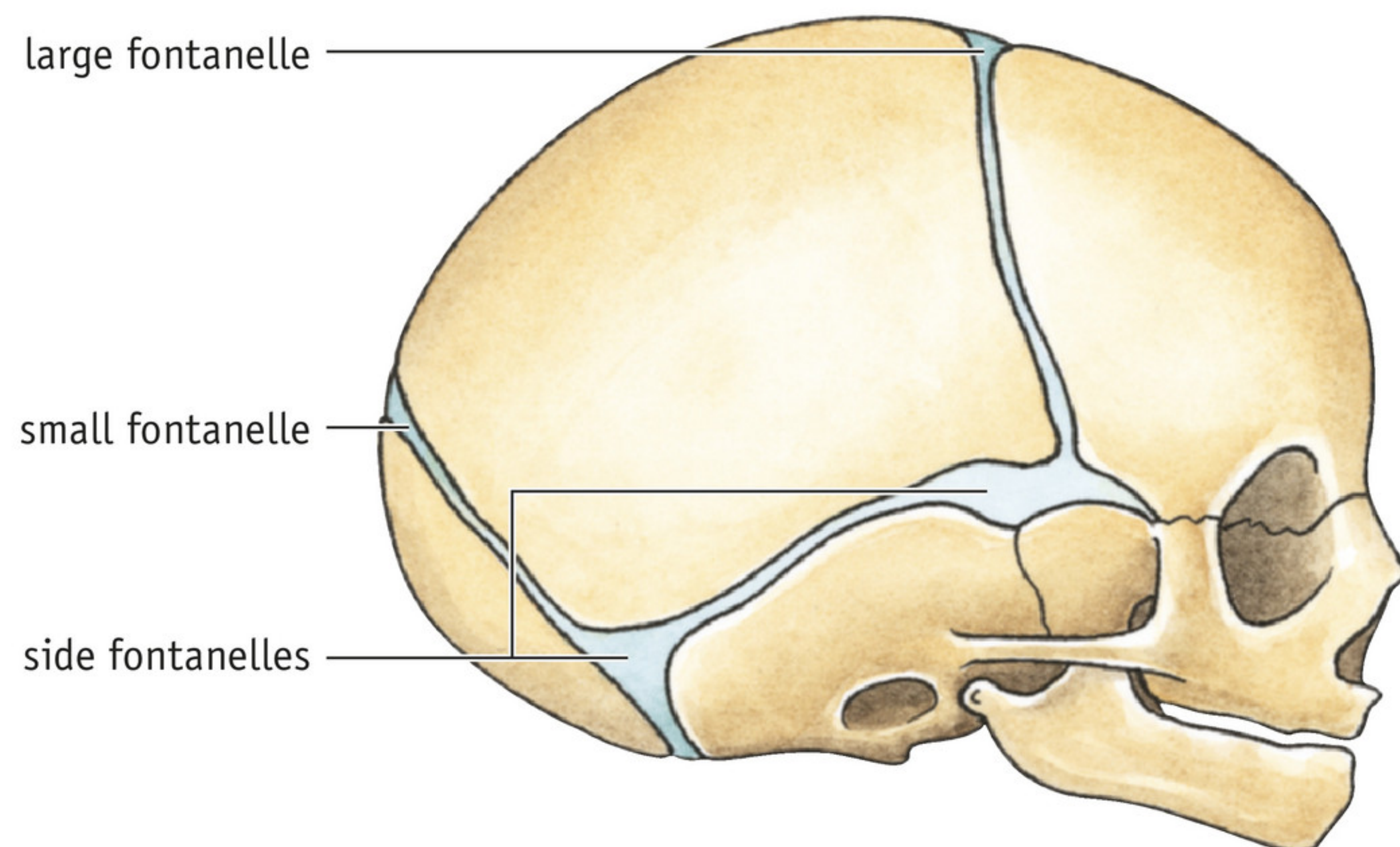


CHANGES IN BONE TISSUE

The bones of a newborn baby consist largely of **cartilage**. As the baby grows, most of cartilage changes to bone. The bones of a baby's skull are not yet fused together. Gaps remain between the bones of the skull for quite a long time. The spaces between the bones are called **fontanelles** (see figure 15). There is connective tissue at these points. The fontanelles have closed up after about 18 months and all you can then see is a suture between the bones. As you get older, the extracellular material of your bone tissue contains less collagen and more calcium phosphate. The extracellular material of children's bones still has a lot of collagen. Bones in elderly people do not have much collagen anymore. Their bones are therefore more brittle and break more easily.

WB EXERCISES 10 TO 12, PAGE 12

► **Fig. 15** The skull of a newborn baby.



4 Joints

Bones can be connected together in various ways. Four types of joints are mentioned in figure 16.

WB EXERCISES 13 AND 14, PAGE 16

▼ Fig. 16

Constructing a skeleton

After cleaning, the next step is to start arranging the bones and building up the skeleton. The loose bones must now be joined together. Some bones are fused together, such as the vertebrae of the sacrum and the coccyx. The bones of the skull are firmly fixed to each other by irregular sutures. At a number of places there is cartilage between the bones. Cartilage lets the bones move a little bit with respect to one another. When setting up a skeleton, the cartilage is often left out or

a plastic replica is used. A lot more movement between the bones is possible at the synovial joints. That is not very helpful in a mounted skeleton. Because there are no muscles to hold the bones in a particular pose, the skeleton would collapse. Mickel therefore connects the bones of these joints together using steel pins. Placing the bones of the joints in a particular position lets Mickel give the skeleton an active pose.



building up a dinosaur skeleton

THE STRUCTURE OF A JOINT

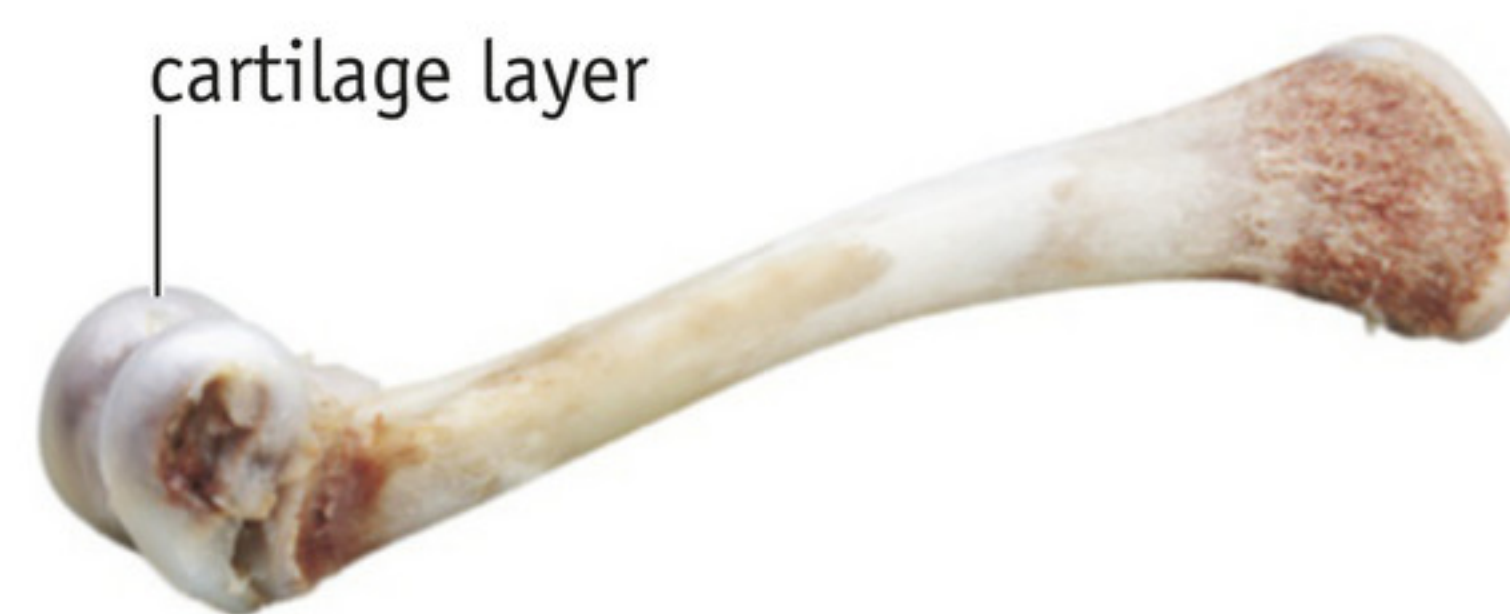
Bones may be **fused** together or may be connected by **sutures**, by **cartilage** or by a **synovial joint**. A synovial is always found between two bones. On one side of the joint there is a **ball-shaped bone** and on the other there is a **socket bone**. The ball-shaped bone and the socket bone are both covered with a layer of cartilage (see figure 17). This lets the bones move smoothly against one another and prevents wear and tear on the bone.

The two bones of a joint are held together by the **joint capsule**. **Synovial fluid** is secreted on the inside of the joint capsule. This is a thick, oily liquid that acts as a kind of lubricant. It lets the bones move smoothly.

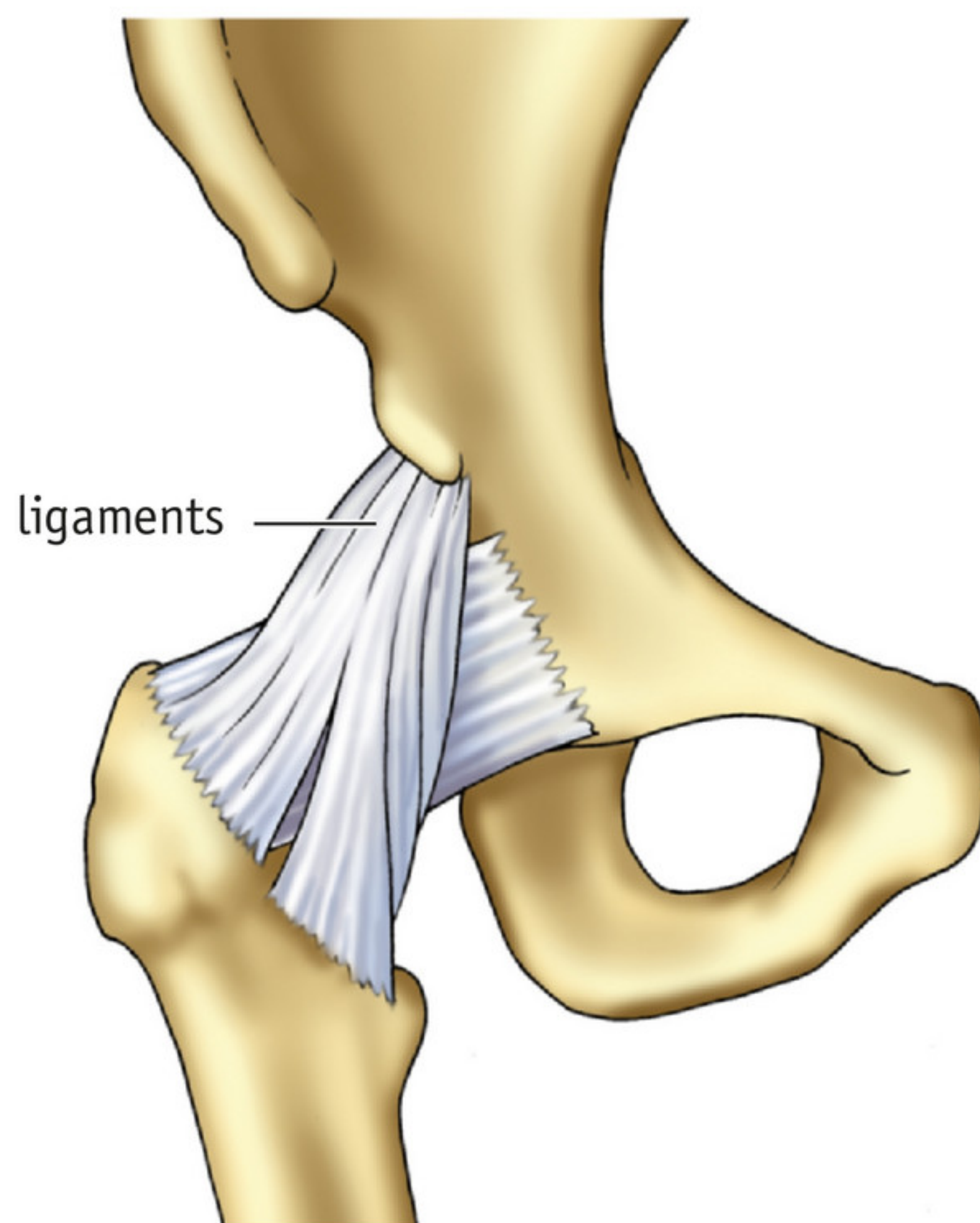
The joint capsule also makes sure that the bones stay in place. Some joints have tough **ligaments** around the joint (see figure 18). These ligaments also help keep the bones in place.

WB EXERCISES 15 AND 16, PAGE 17

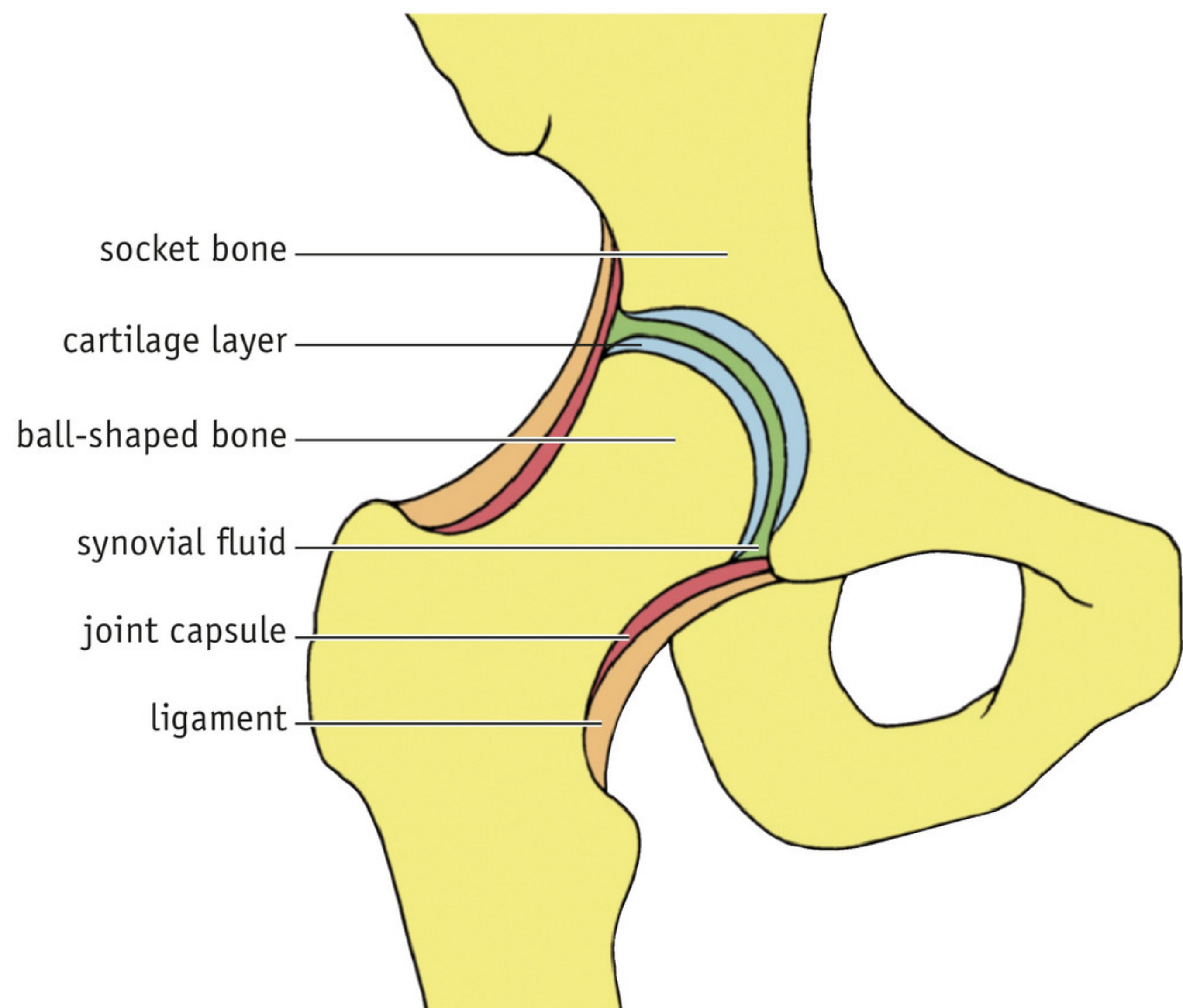
► **Fig. 17** Chicken bone with a layer of cartilage on the head of the bone.



▼ **Fig. 18** The hip joint.



1 external view



2 cross section

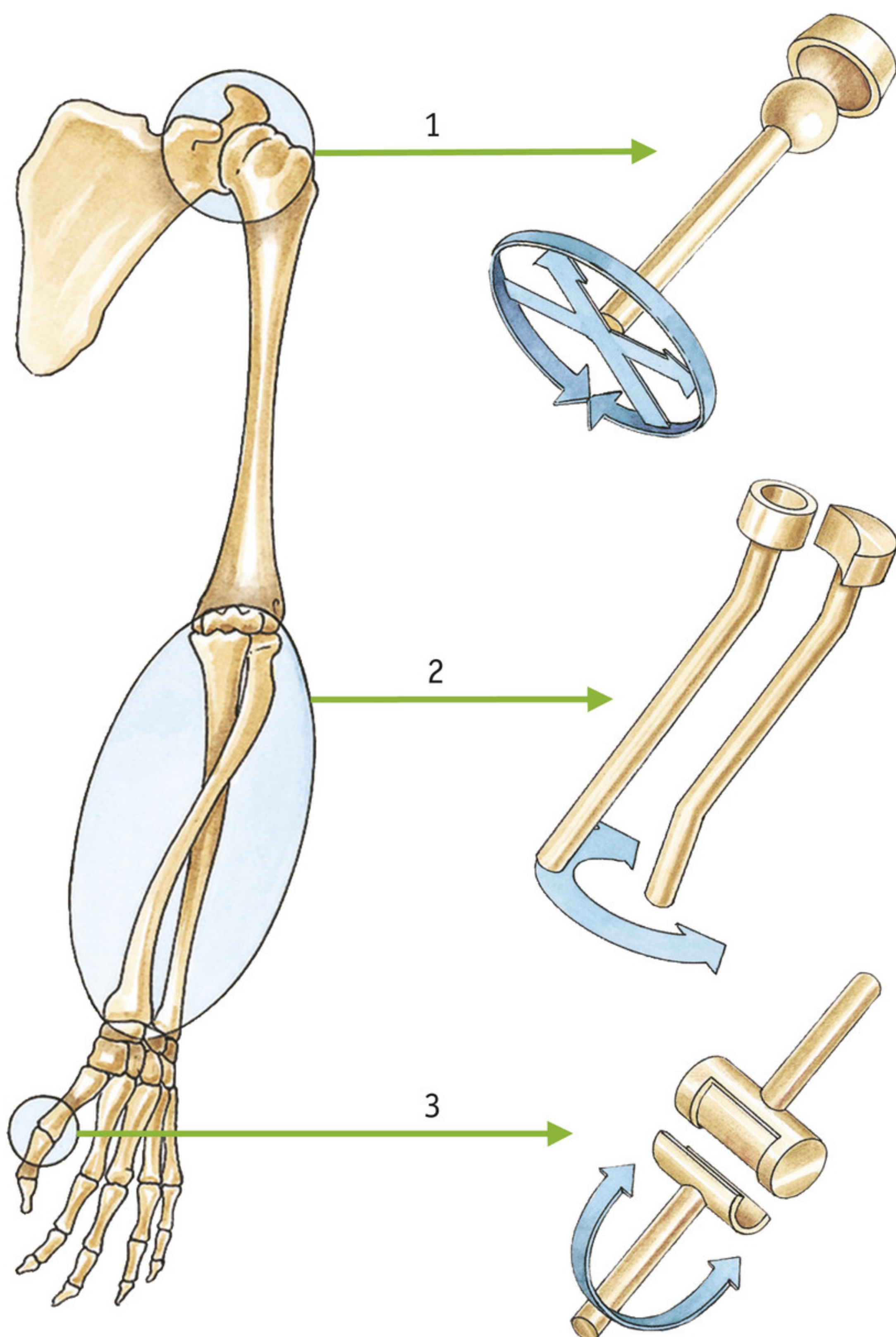
TYPES OF SYNOVIAL JOINTS

The structure of a synovial joint depends on how the bones move with respect to each other. Figure 19 shows three types of synovial joints.

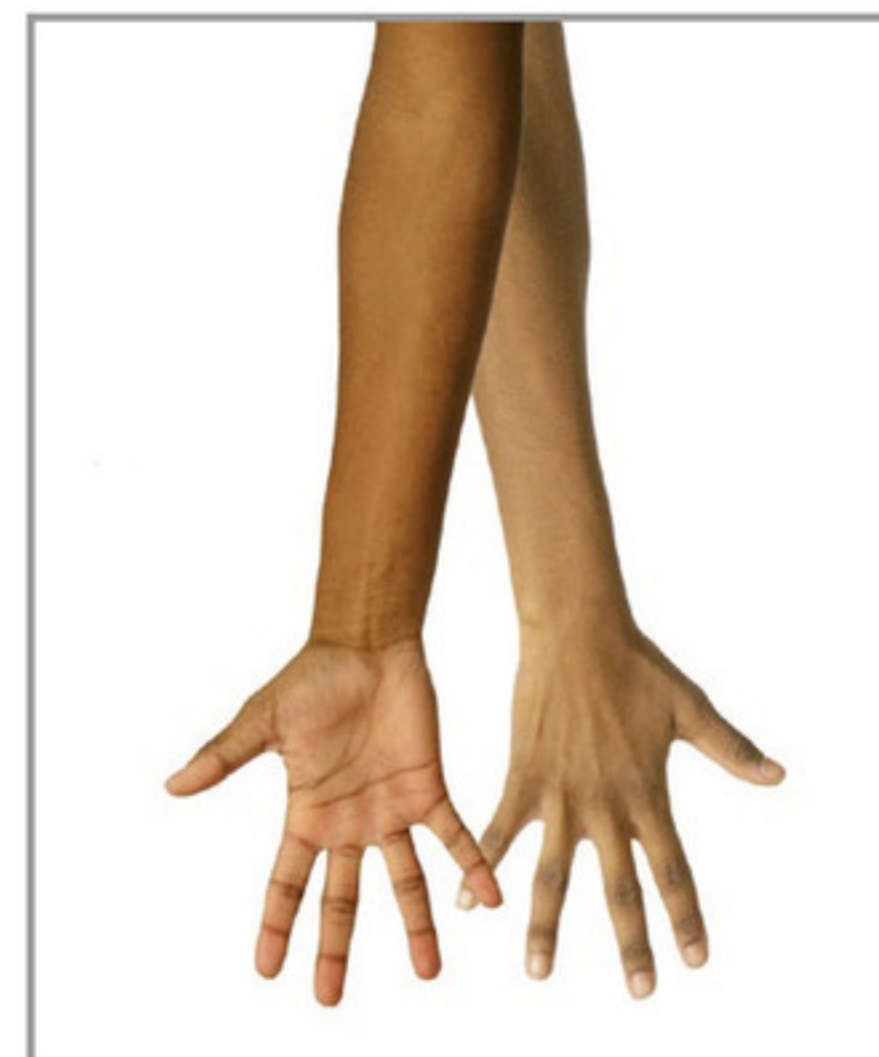
In a **ball-and-socket joint**, the ball-shaped end of one bone rotates in the socket of the other. A ball-and-socket joint allows movement in various directions. In a **pivot joint**, one bone rotates along its lengthwise axis around the other bone. The joint between the radius and ulna in an arm is a pivot joint. In a **hinge joint**, one bone moves like a hinge with respect to the other bone. This means that the only movement it can make is back and forth.

WB EXERCISES 17 AND 18, PAGE 18

▼ Fig. 19 Three types of synovial joints.



1 The shoulder joint is a ball-and-socket joint. Movement is possible in various directions in this kind of joint.



2 The joint between the radius and the ulna is a pivot joint. In a pivot joint, one bone rotates along its lengthwise axis around the other bone.

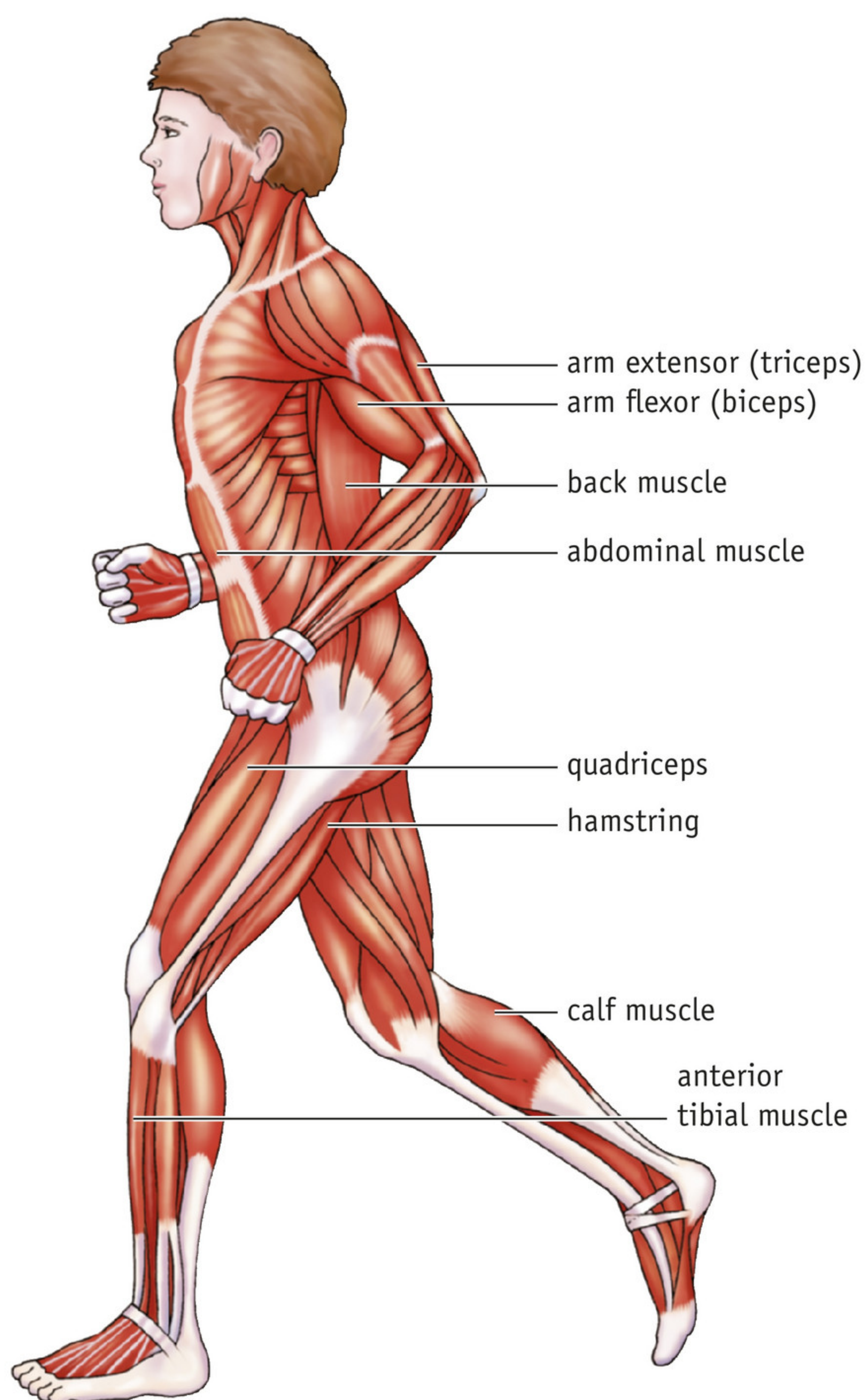


3 The joint between two phalanges is a hinge joint. At a hinge joint, the only movement that can be made is back and forth.

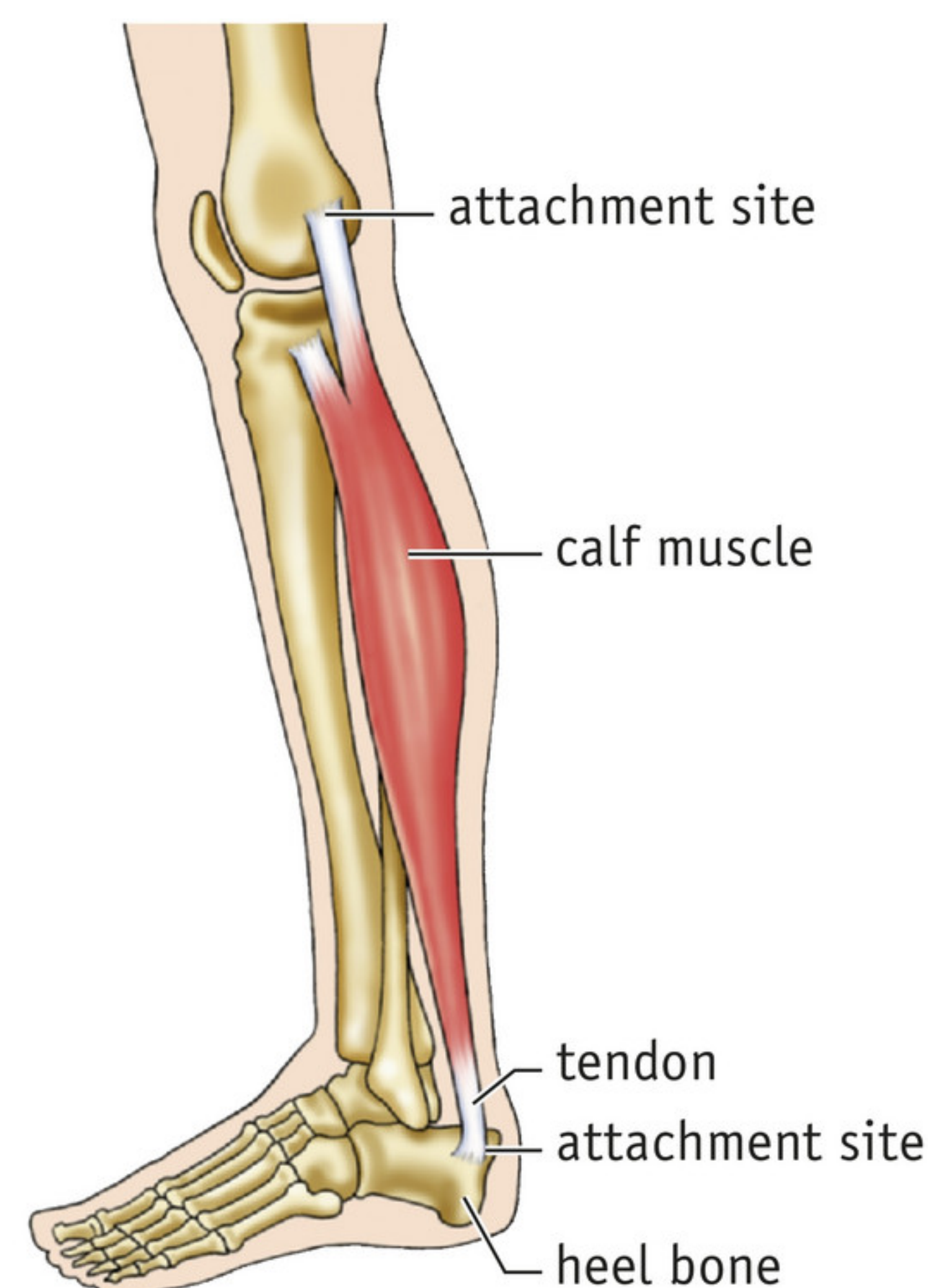
5 Muscles

The bones of your skeleton have muscles attached to them. Muscles are needed if the skeleton is to stand upright and be able to move. Figure 20 shows you the **muscular system**. There are roughly 650 muscles attached to the bones, allowing them to move with respect to each other. Muscles are attached to the bones by **tendons**. The site where a tendon is attached to the bone is called an **attachment site** (see figure 21).

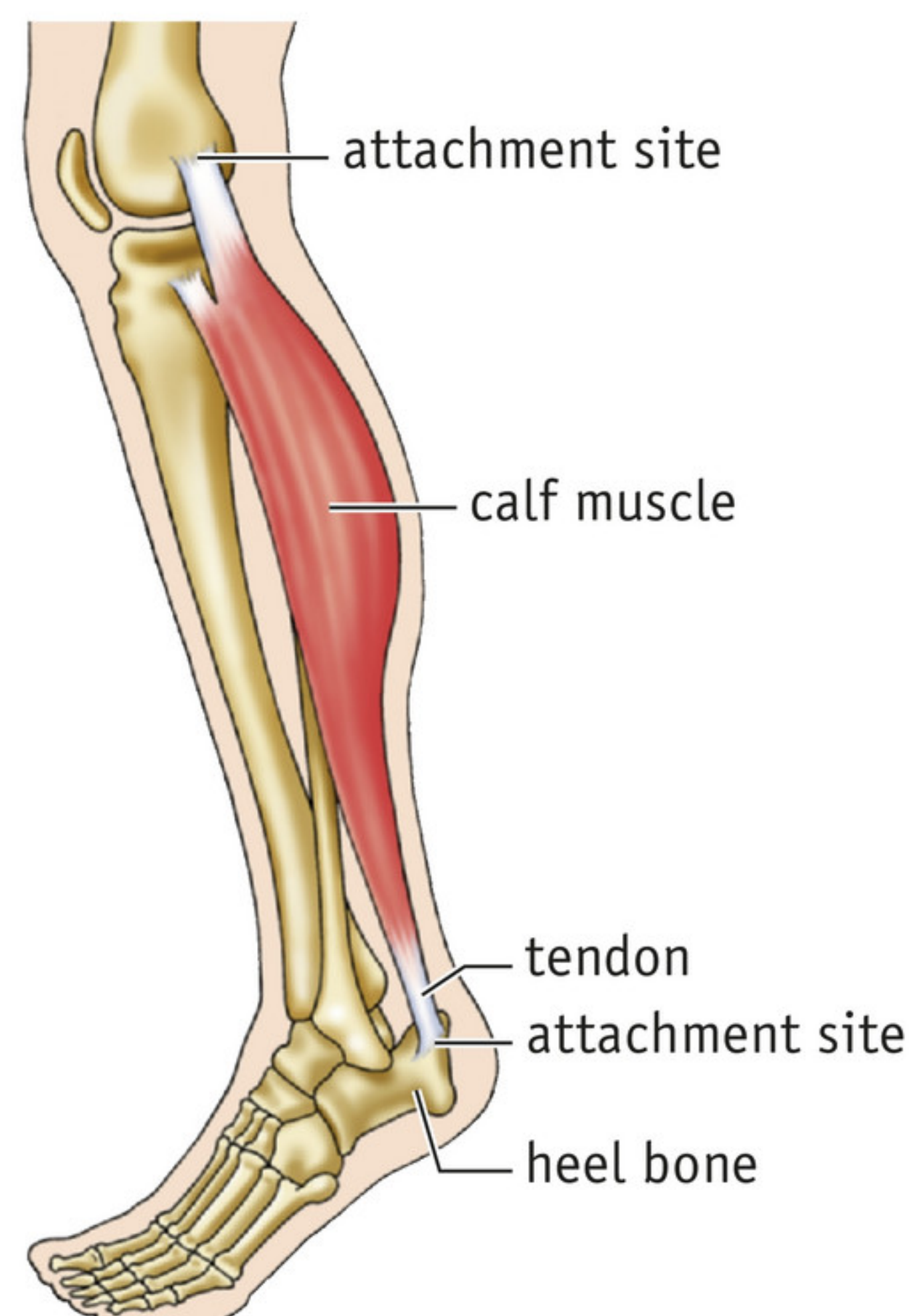
▼ Fig. 20 The muscular system.



▼ Fig. 21 Calf muscle.



1 calf muscle relaxes



2 calf muscle contracts

Muscles are able to contract, but tendons are not. When a muscle contracts, it becomes shorter. The muscle then pulls the bones that the muscle is attached to towards each other. This is how movement occurs.

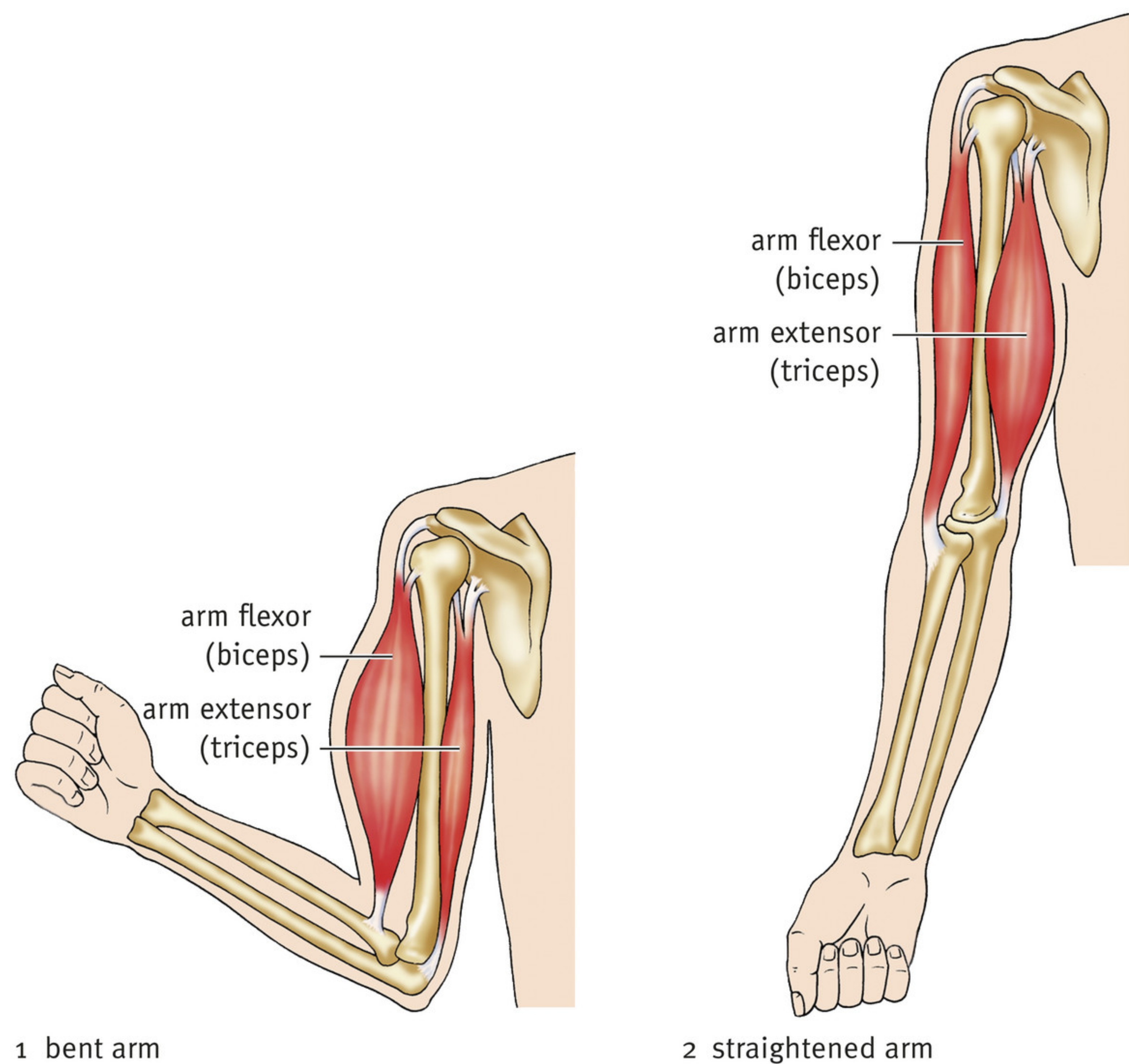
Figure 21 shows you what happens when the calf muscle contracts.

The calf muscle becomes shorter. This decreases the distance between the two attachment sites and the heel bone moves in the direction of the thighbone. The foot then straightens and the body is lifted.

Figure 22 shows you the muscles in the upper arm. You can move your forearm thanks to these muscles. One of these muscles is called the **biceps**. When it contracts, the arm bends (flexes). This is why the biceps is also referred to as the arm flexor muscle.

The biceps is not able to push the forearm back into the straightened position. A second muscle is needed to extend the arm again. The muscle that extends the forearm is called the **triceps** or the arm extensor muscle. Muscles that produce opposite effects when they contract are called **antagonistic muscle pairs**.

► **Fig. 22** Upper arm muscles.



The large muscles that you use to make your skeleton move are called the **skeletal muscles**. You have all sorts of muscles at other places, in addition to the skeletal muscles. When you eat, there are muscles that move the food through the digestive tract. These muscles are in the wall of the gullet, the stomach and the intestines. Your heart is also a muscle. When it contracts, your heart pumps blood through the body. These muscles move without you being aware of it.

6 Posture and movement

The skeleton is robust and muscles are strong. Nevertheless, many people have complaints that are related to the skeleton or the muscles. This can have a variety of causes. If a muscle is not used for a long time, for instance because of a plaster cast, then the muscle will become weaker (see figure 23). Muscles can then get overworked, which you will notice because they hurt.

▼ Fig. 23

Fitness in space

Astronauts sometimes spend months in space. They are weightless out there and very little strength is needed to move and to keep the body upright. When you train your muscles, more muscle fibres are produced. The muscles then become thicker and are able to exert

more force. The opposite happens to muscles that are not used. The number of muscle fibres diminishes, and the muscles therefore become thinner and weaker. To make sure that the muscles do not lose too much strength, the astronauts do fitness exercises.



1 fitness in space



2 after coming back from a mission in space, the Dutch astronaut André Kuipers could no longer walk

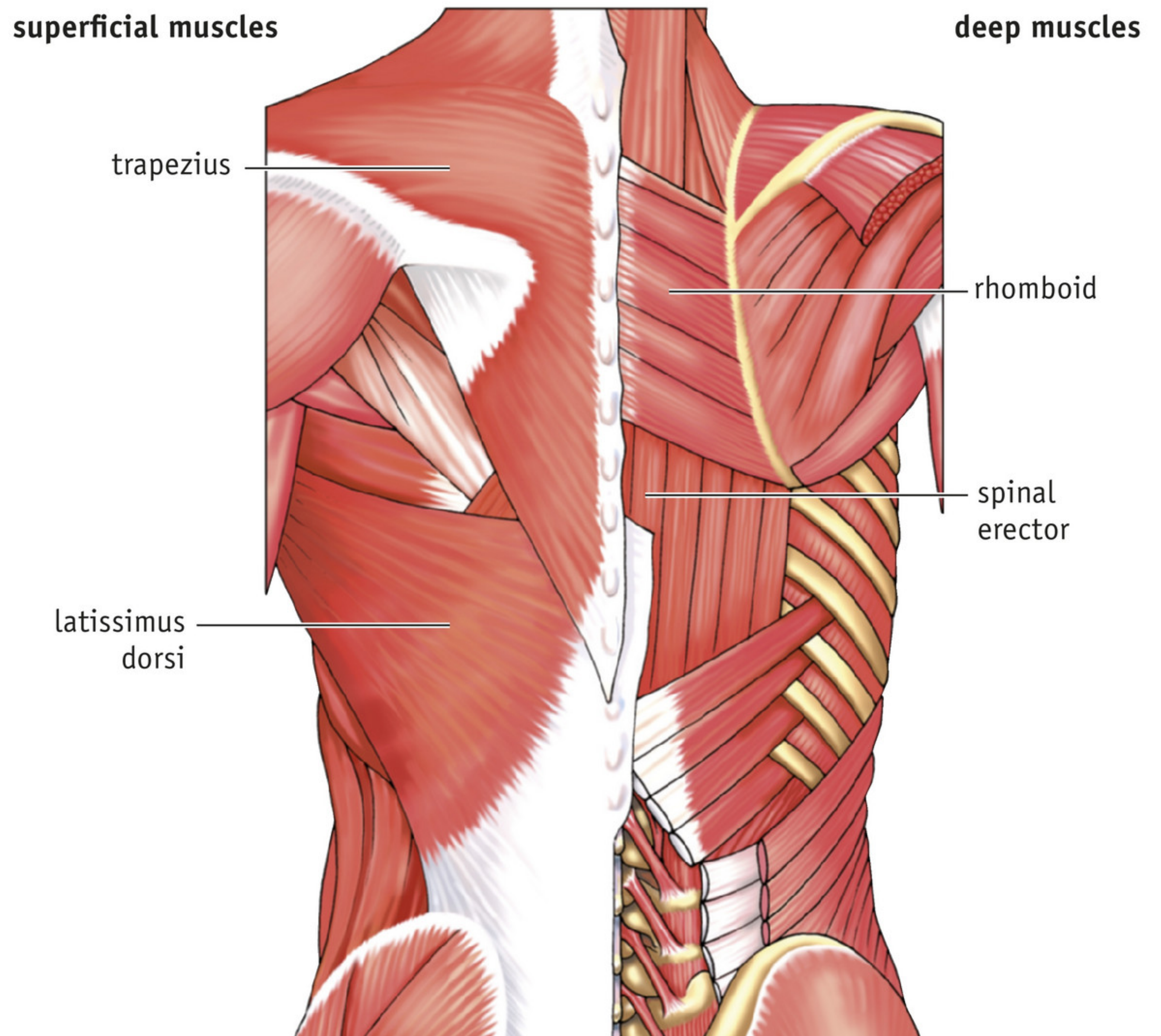
▼ **Fig. 24** The backbone has a double-S shape.



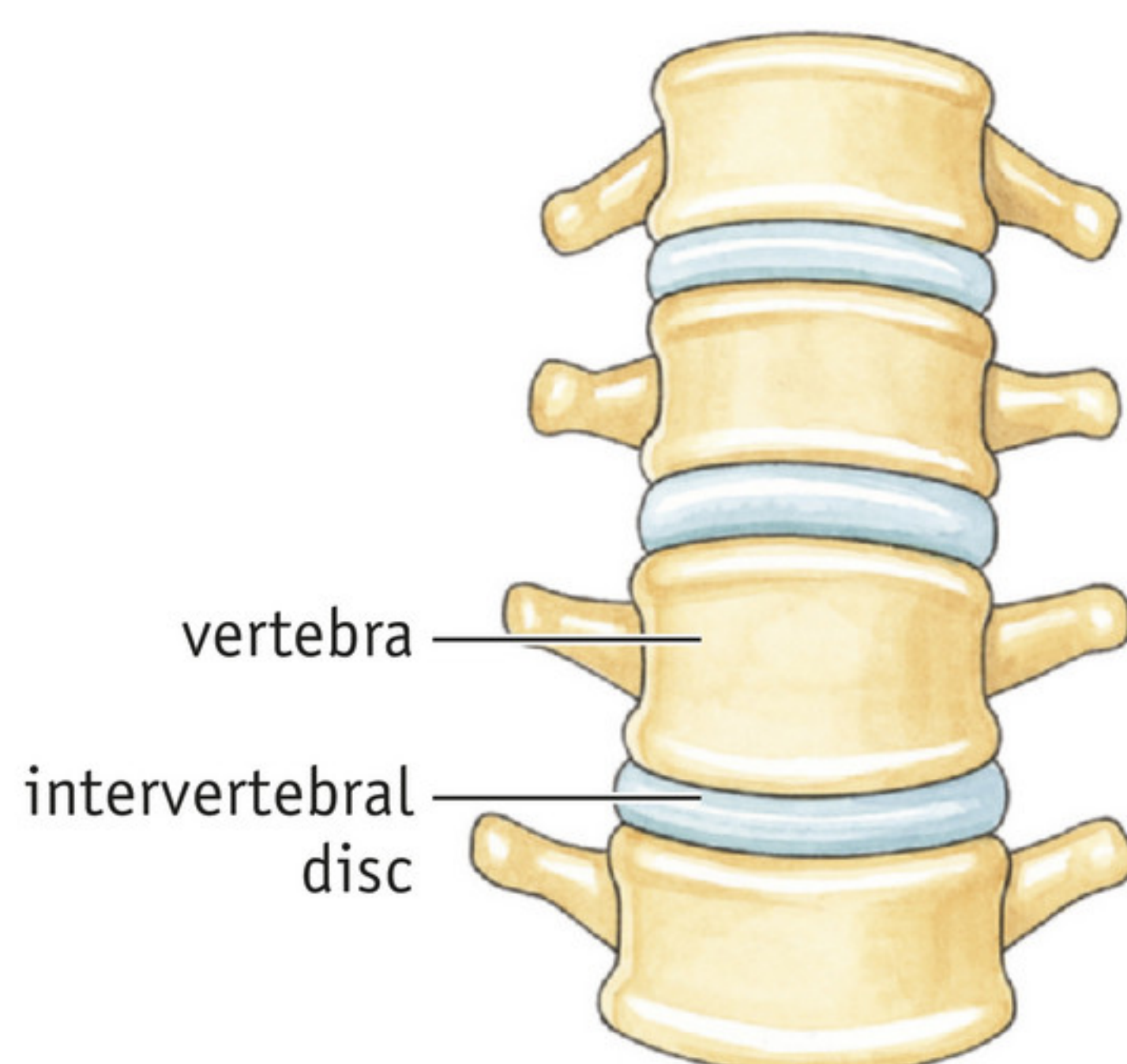
POSTURE

You have learned how the backbone is made up. The shape of the backbone looks like two letter S's, one above the other (see figure 24). We call this the **double-S shape**. This shape is maintained by the back muscles that are connected to the vertebrae (figure 25). You have also learned that the vertebrae have cartilage pads between them. The discs of cartilage between your vertebrae are called the **intervertebral discs** (see figure 26). Intervertebral discs are a kind of shock absorber. The double-S shape and the intervertebral discs make the backbone flexible. They absorb the impacts caused by you walking.

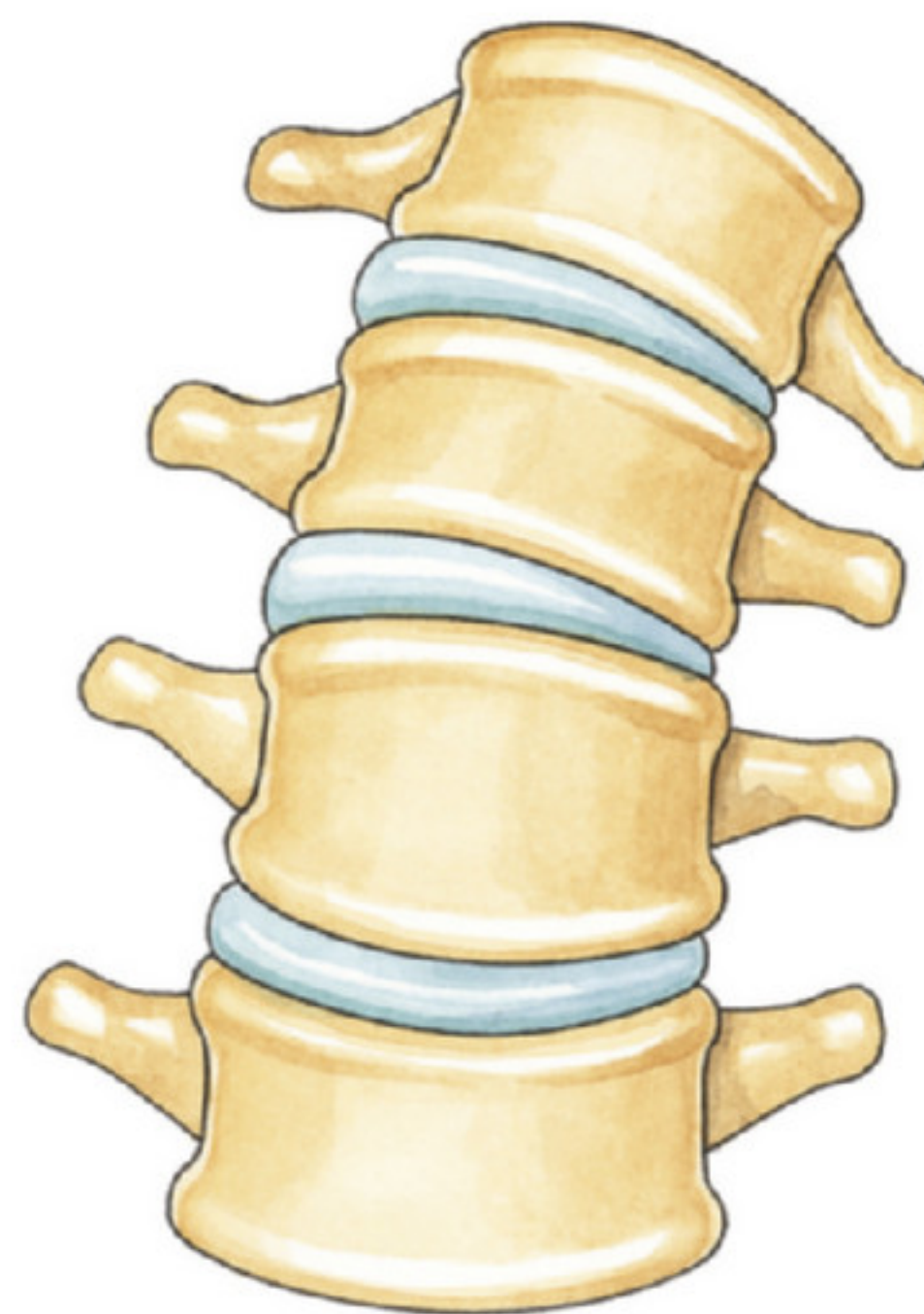
▼ **Fig. 25** Back muscles.



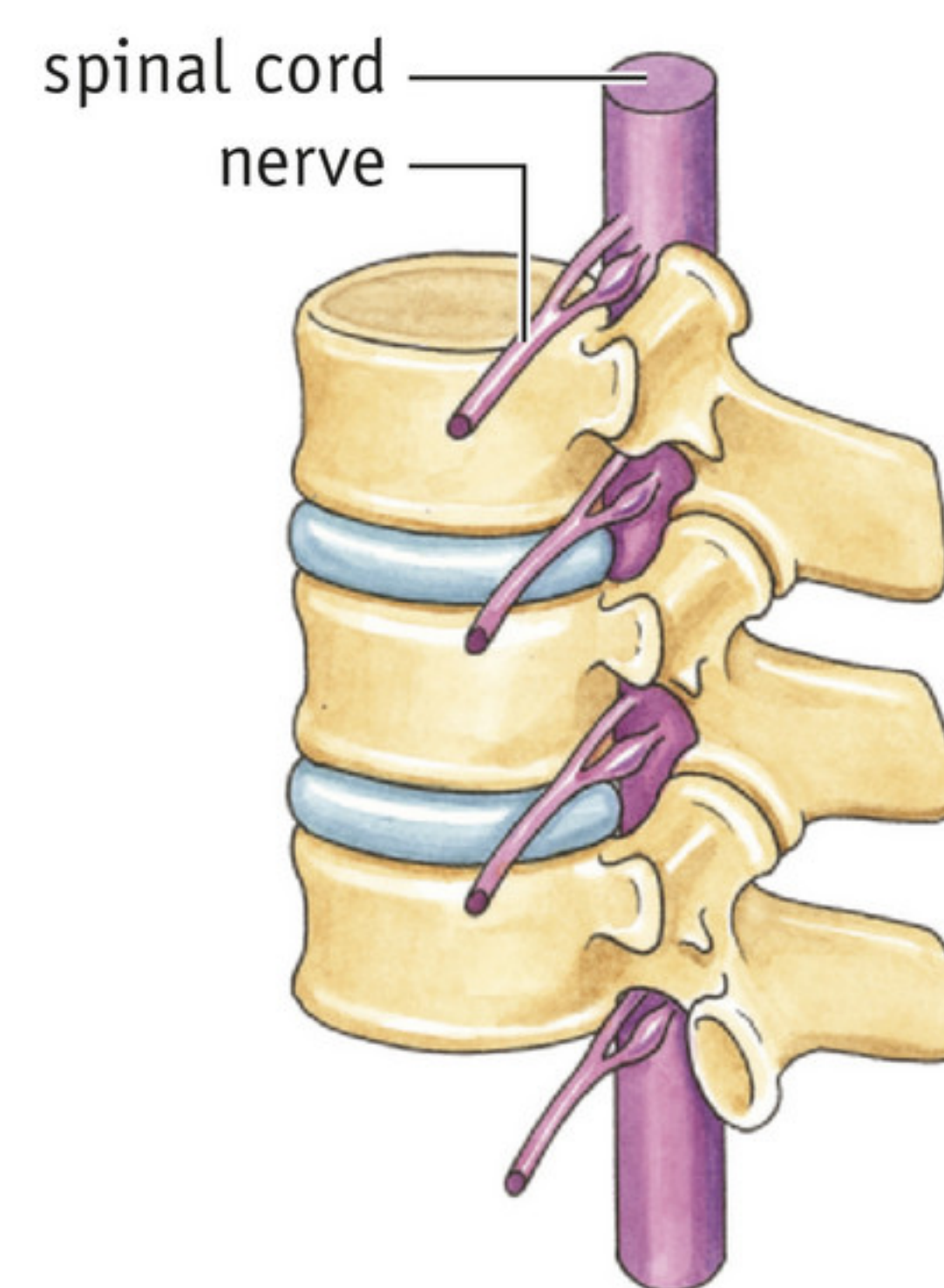
▼ **Fig. 26** Vertebrae and intervertebral discs.



1 back straight



2 back bent



3 spinal cord

If the muscles are not very strong, it is more difficult to maintain good **posture**. Bad posture can mean that one side of the spinal column is more heavily loaded than the other. Some of the muscles will then have to work harder. The intervertebral discs are then more heavily loaded on one side too (see figure 26). This can cause all kinds of complaints over the course of time, such as back pain. A GP (general practitioner) will then often refer someone to a physiotherapist, who can give advice about good posture and get them to do exercises to strengthen the muscles (see figure 27).

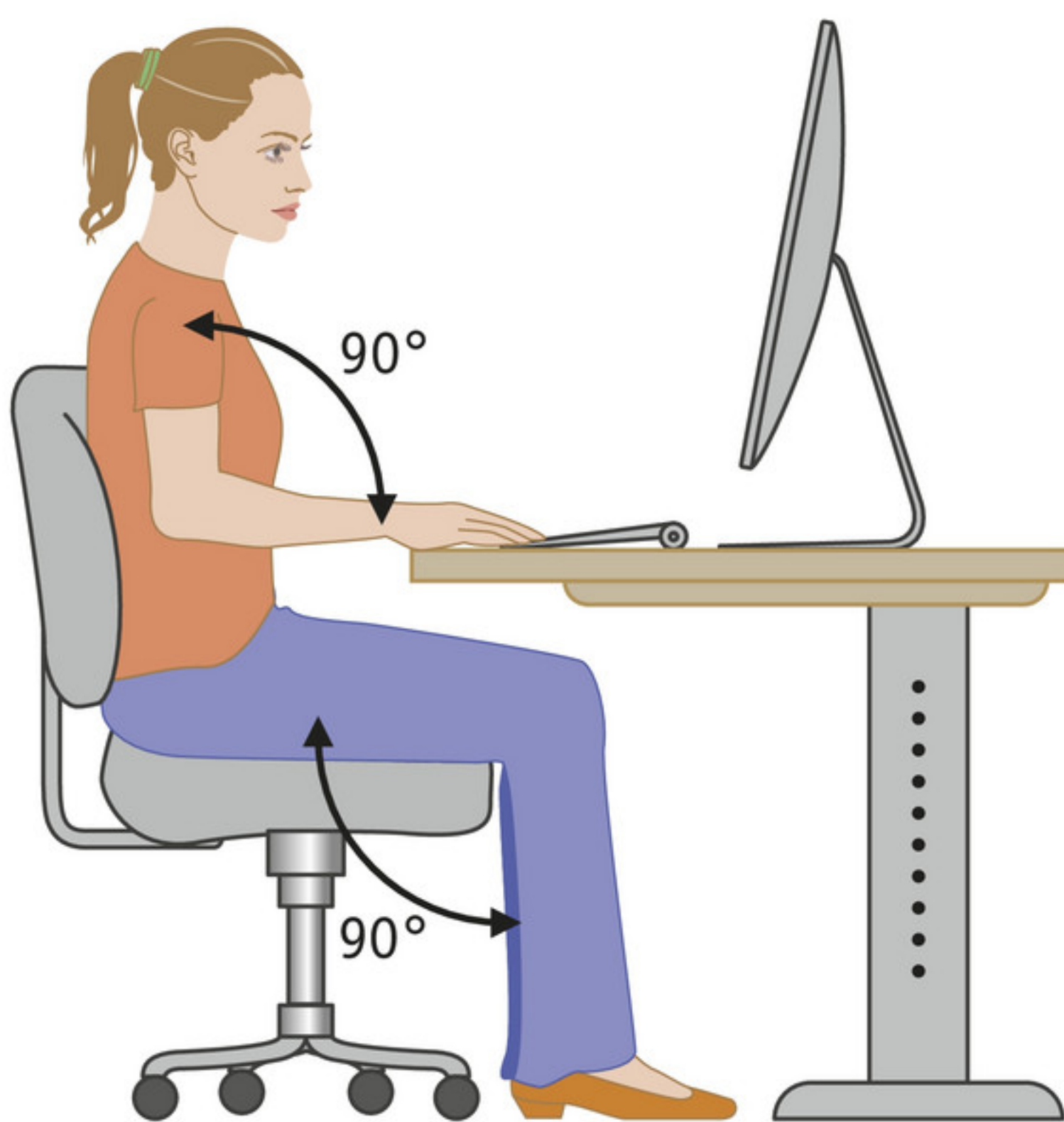
▼ Fig. 27

Physiotherapist

Hallo, I'm Eefke. I am a physiotherapist, which means that I treat patients who have problems with their movements. There can be all kinds of reasons for these problems. An accident is often the cause, requiring someone to lie in bed for a long time. Or they may have had a plaster cast. I also treat a lot of people with back complaints. During treatment, I get the patients to do exercises, which strengthens the muscles. I give them advice about staying fit too. I also use massage techniques and equipment that stimulate the blood circulation. The aim is for the patients to get stronger muscles and be fitter. This often reduces the complaints.



▼ Fig. 28 A good sitting posture.



A good **sitting posture** can help prevent back complaints. This is important in the classroom too. The correct way is to sit up straight with an angle of at least 90° between your upper and lower leg. If you have your upper arms alongside your body and your forearms on the desk, they should be at an angle of 90° to your upper body (see figure 28).

LIFTING

A lot of people who often have to lift heavy objects get back complaints later in life. This is often because they do not lift things properly. When lifting, it is important that the backbone keeps the double-S shape as much as possible. Figure 29 gives ten rules for the right way to lift things.

WB EXERCISES 22 TO 25, PAGE 22

▼ Fig. 29

TEN RULES FOR SENSIBLE LIFTING

- 1 Don't bend and lift if you don't have to.



- 2 Use equipment when needed.



- 3 Do not lift too much at once.



- 4 Make sure nothing is in your way when you are walking with a load.



- 5 Always stand straight in front of the load.



- 6 Never lift when your back is twisted. Move your feet if you have to turn round.



- 7 Use both arms when lifting and keep the load as close to your body as possible.



- 8 Do not bend further forward than you have to and use your leg muscles as well when lifting.



- 9 Avoid having to stretch or reach: do not lift heavy objects above shoulder height.



- 10 Listen to your body: take the signals seriously. Small complaints can easily get worse. Your back will tell you what it can manage and what it can't.

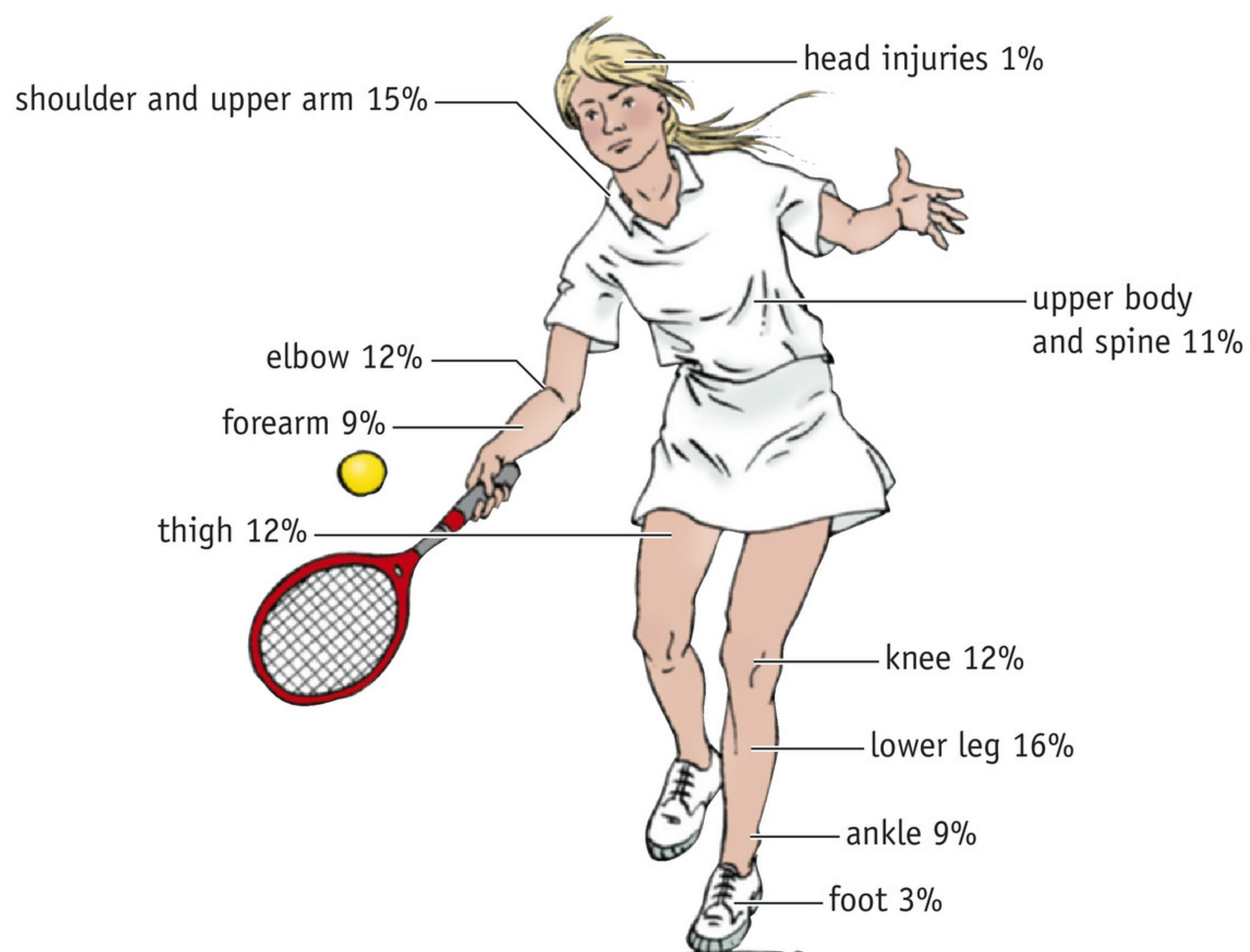


7 Injuries

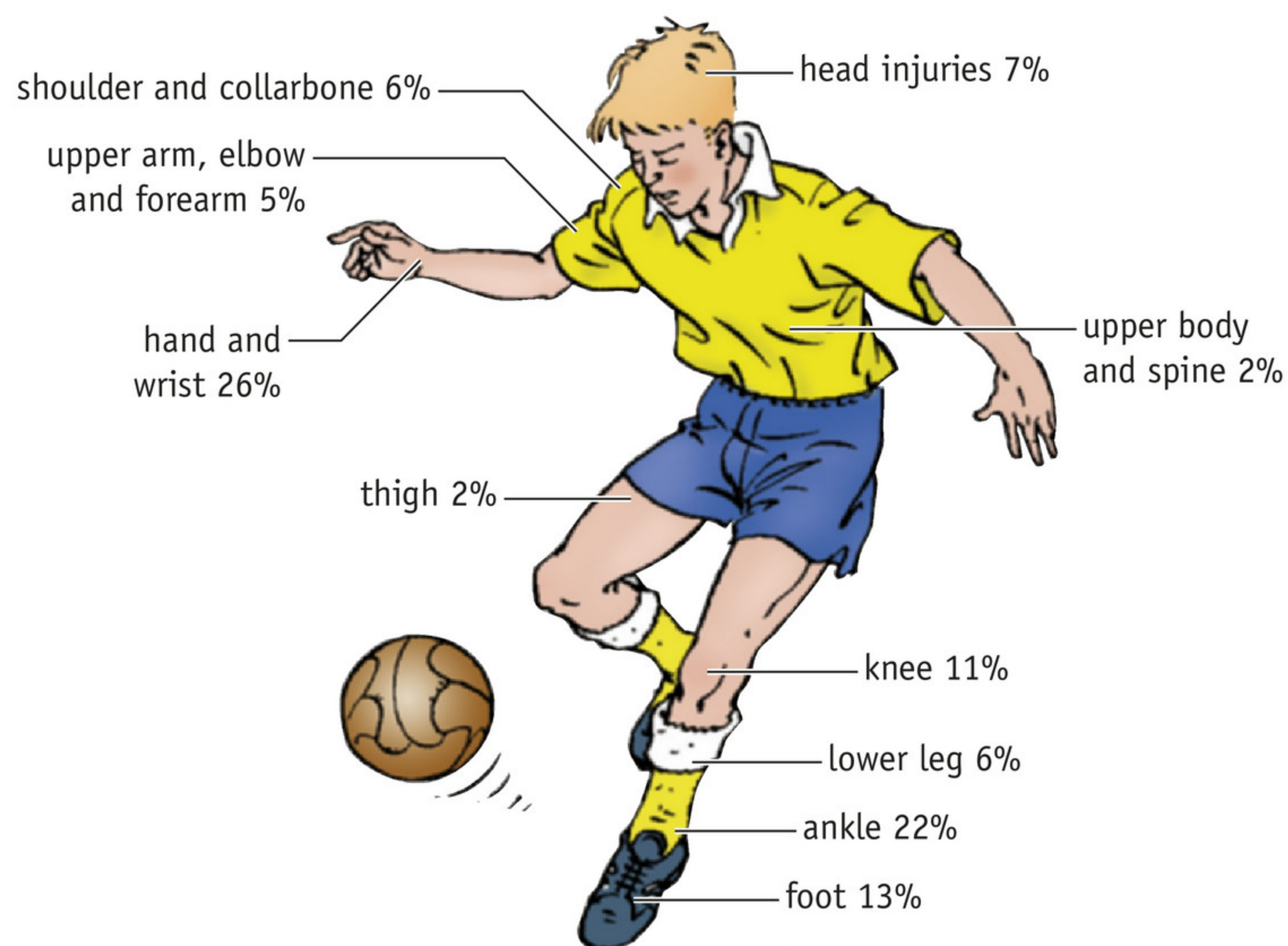
Things can sometimes go wrong when taking part in sports. You can get sore muscles or an **injury**.

The number of sports injuries in the Netherlands is estimated at 3.5 million a year. About 1.5 million people need medical treatment for sports injuries. In the Netherlands, the number of injuries playing football is about 540,000 per year and about 200,000 playing tennis. Figure 30 shows you which parts of the body get injured most often when playing tennis and football.

► **Fig. 30** Risk of injury for specific parts of the body.



1 when playing tennis



2 when playing football

If you play sports, you may get **sore muscles**. Sore muscles often happen after an effort that you are not used to. They can also be caused when the muscles cool down a lot, for instance if you go to sleep lying in a draught. We then say that the muscles are stiff.

Muscle pain can also be caused by damage to a muscle.

Overdoing the effort or training, or a sudden movement, can cause a **muscle strain** or rupture. You might for example 'pull' your calf muscle. A pulled muscle generally recovers if it gets rest. In severe cases, a pressure bandage is used.

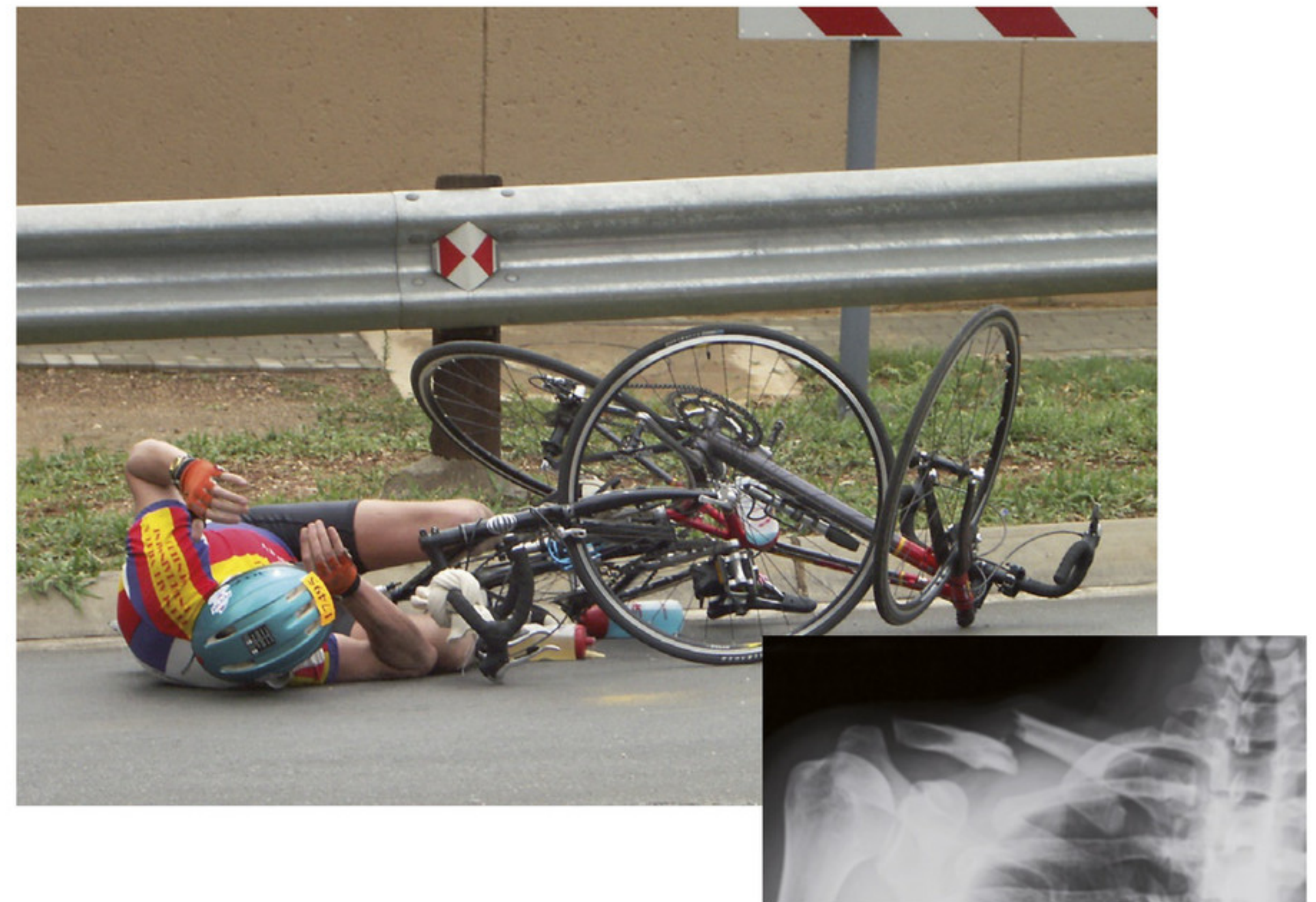
As well as muscle injuries, you can also damage your bones, joints and ligaments. Racing cyclists often get **fractured** bones if they have a fall, particularly fractures of the collarbone. In footballers, fractures of the tibia and fibula are common. This is generally the result of hard or foul play. Bone fractures are easy to see on X-ray photos (see figure 31).

▼ **Fig. 31** Broken bones in sports.



1 footballers often break their fibula

2 X-ray



3 racing cyclists often break their collarbone

4 X-ray

▼ **Fig. 32** Screws and plates may be needed to mend a broken bone.



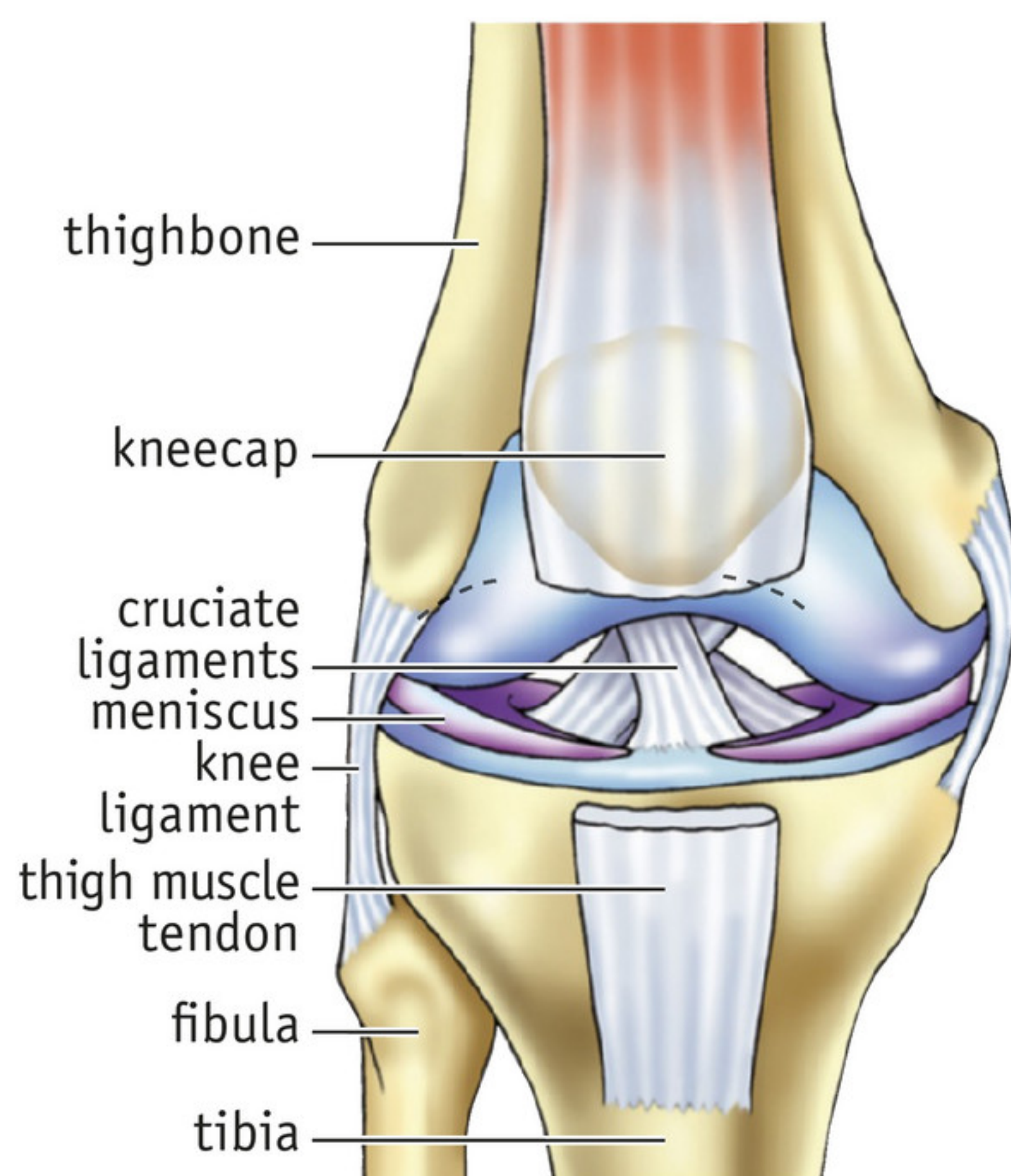
For the bone to heal properly, the two halves must be aligned correctly as they grow back together. If the two parts of the bone are not lined up correctly, you have to go to the hospital to **set** the bone properly again. The two halves of the bone are generally held in the right place with a plaster cast. If that does not work, screws and plates or pins may be used to immobilise the bone (see figure 32).

RUNNER'S KNEE

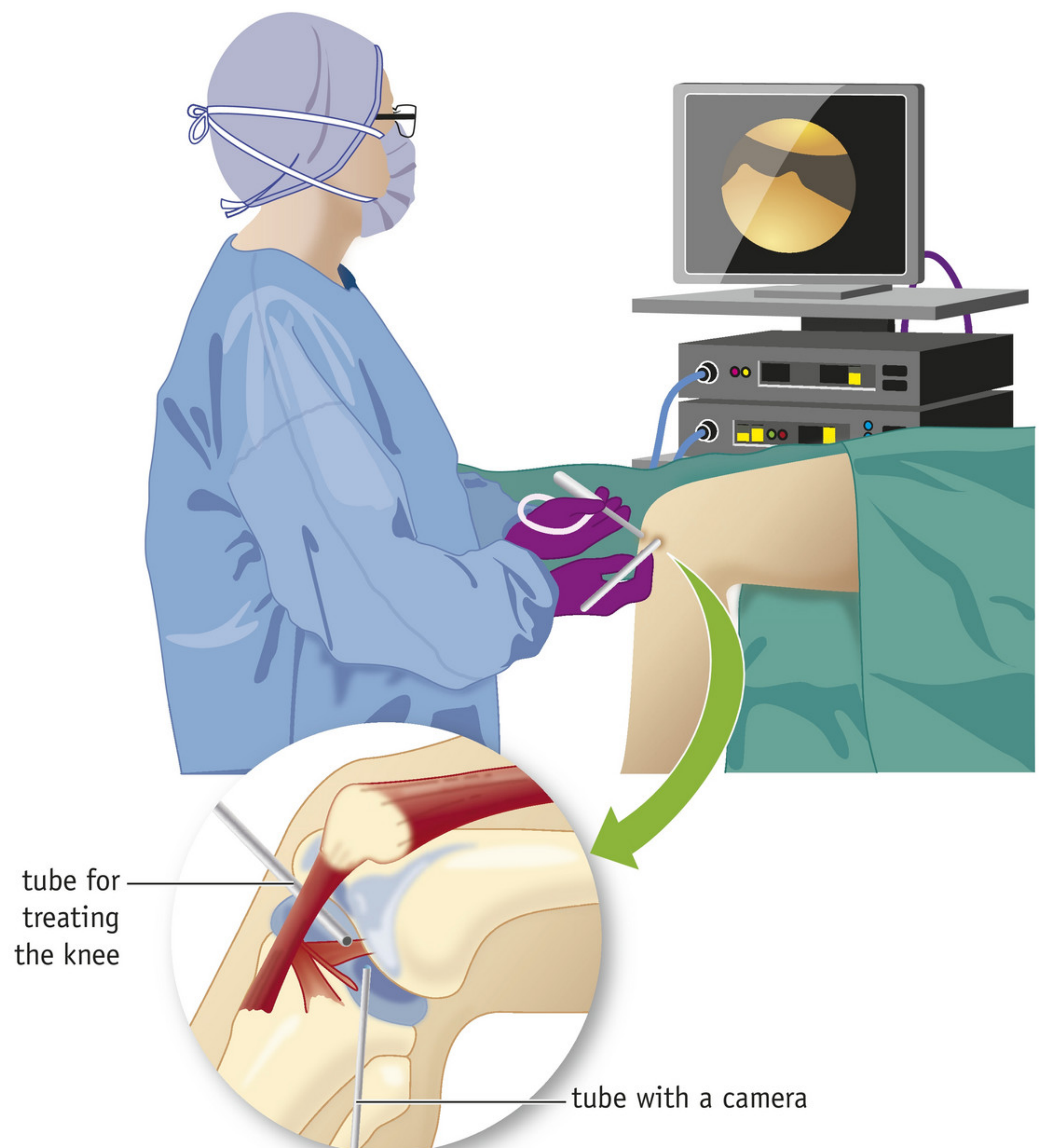
A **runner's knee** is one of the most common injuries. The knee joint has two discs of cartilage between the thighbone and the tibia. A disc of cartilage in the knee is called a **meniscus** (see figure 33). If the body turns around while the lower leg stays in place, a meniscus can tear. This is very painful. There is then usually also damage to the joint capsule and the ligaments (the **knee ligaments** or the **cruciate ligaments**). Accumulation of fluid in or around the knee causes the swelling that is known as 'water on the knee'. It is also possible that a piece of the meniscus that has come loose will prevent the knee from straightening. We say that the knee is 'locked'. Sometimes rest is enough to let the knee joint heal, but a torn meniscus often needs to be treated surgically. Nowadays that can be done with keyhole surgery. A specialist makes a small incision through which a tube containing a camera is inserted into the knee. A second tube can then be used for treating the knee (see figure 34).

WB EXERCISES 26 TO 29, PAGE 26

▼ **Fig. 33** Knee joint.



▼ **Fig. 34** Keyhole surgery.



OTHER INJURIES

A **bruise** or **contusion** is damage to tissue without anything being torn or broken. Bruises generally occur when you get a knock, blow or kick. In a bruise, the tissue swells up because of internal bleeding that accumulates in the tissues. You can reduce this swelling by cooling the bruised area (see figure 35). Treatment with an ice pack (cold compress) reduces the internal bleeding. On top of that, the ice pack reduces the pain. After that, rest will heal the injury. Medical assistance is needed for severe muscle strains and sometimes even an operation.

► **Fig. 35** Treating a bruise in a footballer.



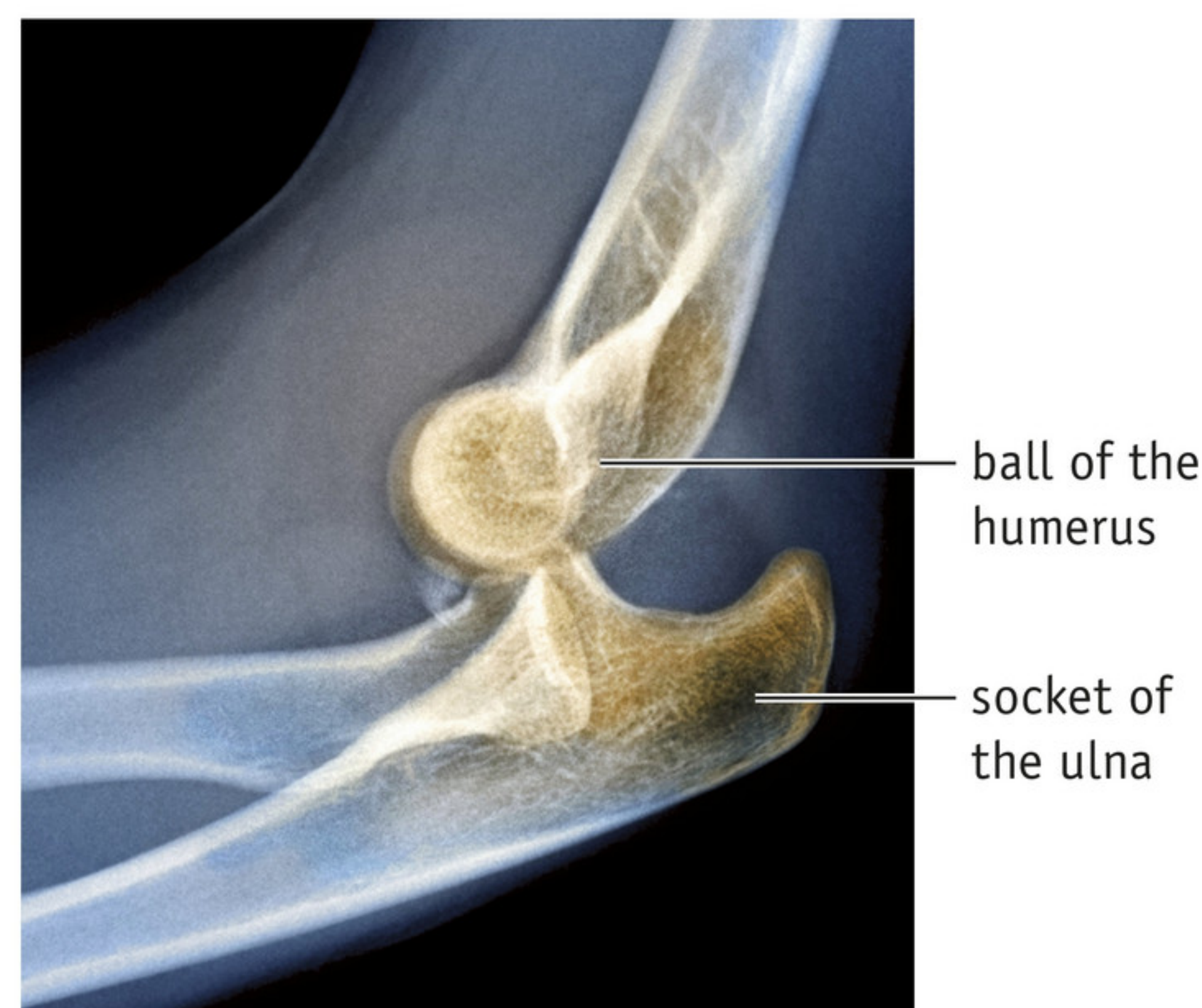
▼ **Fig. 36** A bruise due to a sprain.



A **sprain** is a bruise to a joint. If you twist your ankle, for example, the joint capsule and the ligaments at your ankle can get overstretched. You may then see a bruised area (see figure 36). If the sprain is severe, the joint capsule and the ligaments may tear. You have then torn your ankle ligaments.

In a **dislocation**, the ball of the joint has come out of its socket (see figure 37). Dislocations can occur for instance if you fall wrongly on your arm. The shoulder can then get dislocated. A doctor then has to put the ball end of the humerus back in place in the socket of the shoulderblade.

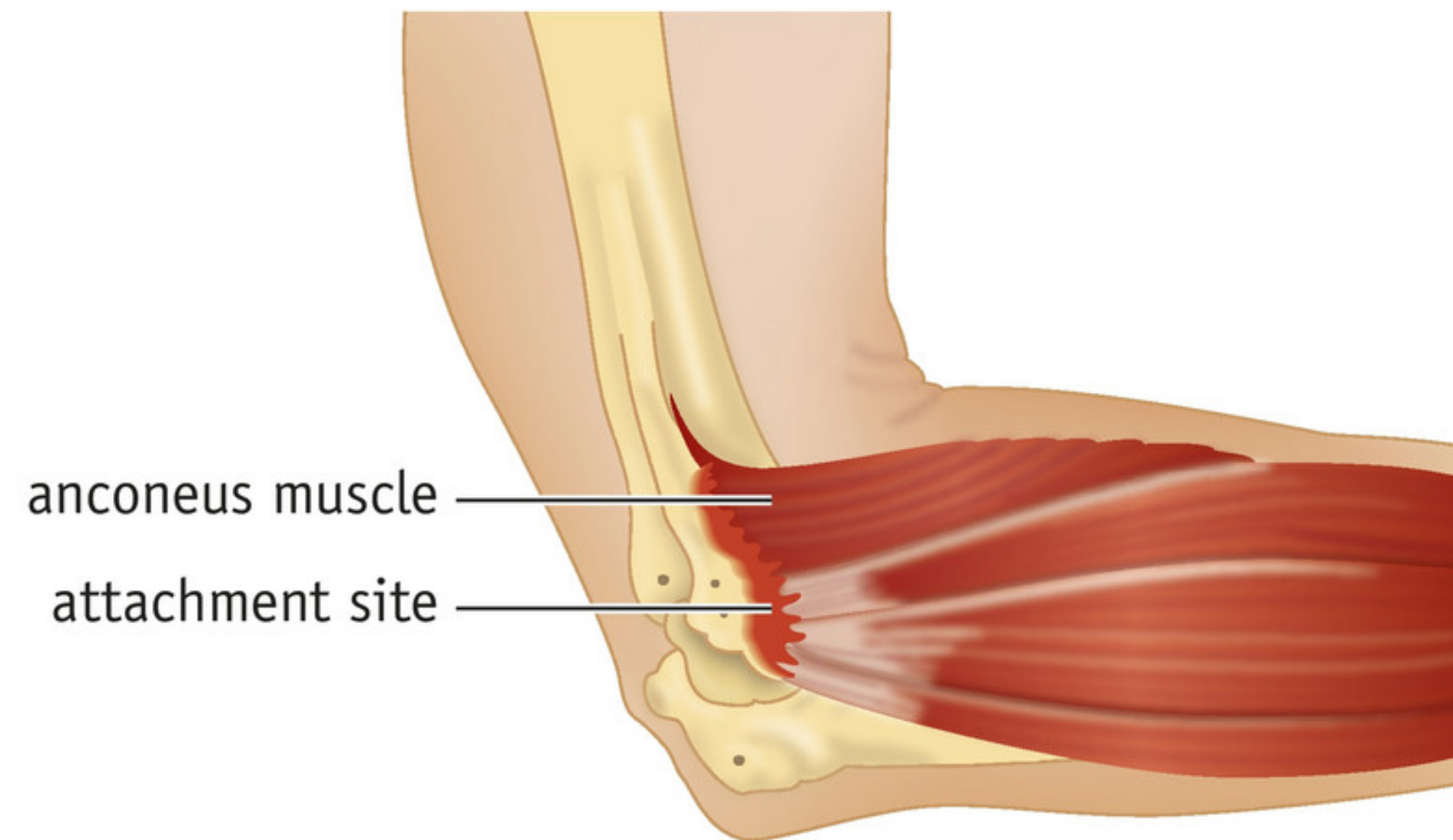
▼ **Fig. 37** A dislocation.



TENNIS ELBOW

Another common injury is **tennis elbow**. If someone is complaining of pain on the outside of the elbow, this can be a sign of tennis elbow (see figure 38). It also hurts if pressure is exerted on this point.

► Fig. 38



1 tennis elbow



2 heavy use of smartphones can cause RSI

The elbow is the attachment site for the muscles that move the wrist and fingers. Tennis elbow makes extending the wrist particularly painful. Golfer's elbow is a condition that is similar to tennis elbow; in this case, it is bending the wrist and fingers that hurts. Overstressing the tendons and muscles of the forearm is the cause. This is generally the result of frequently repeating the same motion or by tensing the muscles for long periods.

Tennis elbow occurs regularly among people who have to repeat the same movement very frequently as part of their job, such as a painter or window cleaner. Working with a computer and mouse is also often mentioned as a cause.

▼ Fig. 39

CAUSES OF SPORTS INJURIES

- 1 Rough play and breaking the rules (unsporting behaviour).
- 2 Poor training and inadequate technique.
- 3 Lack of fitness.
- 4 Overuse of muscles and fatigue.
- 5 Insufficient warming up, stretching and/or cooling down.
- 6 Bad weather conditions (rain, cold or ice).
- 7 Resuming sports too quickly after an injury.
- 8 Poor sports kit (e.g. old equipment or wrong footwear).

Young people play a lot of games on smartphones, tablets, game consoles, laptops and PCs, for instance. This also often involves making particular movements repeatedly and it can also result in tennis elbow. Other complaints can also arise, such as shoulder pain, back pain and even headaches.

If an injury is the result of repeatedly doing the same movement, it is referred to as **RSI** (repetitive strain injury). RSI as a result of working with a computer is also called **mouse elbow**. Good posture while sitting at the computer reduces the risk of getting a mouse elbow.

CAUSES OF SPORTS INJURIES

Various factors often play a role at the same time in sports injuries. Figure 39 summarises a number of key causes.

You can do a lot yourself to avoid sports injuries, for example by **warming up** before a match or a training session. You then do a series of exercises to loosen up your muscles and warm them up. Warming up should also include **stretching** exercises. You should also do **cooling-down** exercises after a match or training session. The text in figure 40 is from a brochure about warming up, stretching and cooling down.

▼ Fig. 40

WB EXERCISES 30 AND 31, PAGE 29

WARMING UP, STRETCHING AND COOLING DOWN

Doing sports asks a lot of your muscles. Luckily they're able to do a great deal, as long as they're treated properly. Especially before and after sports, by warming up, stretching and cooling down.

WARMING UP

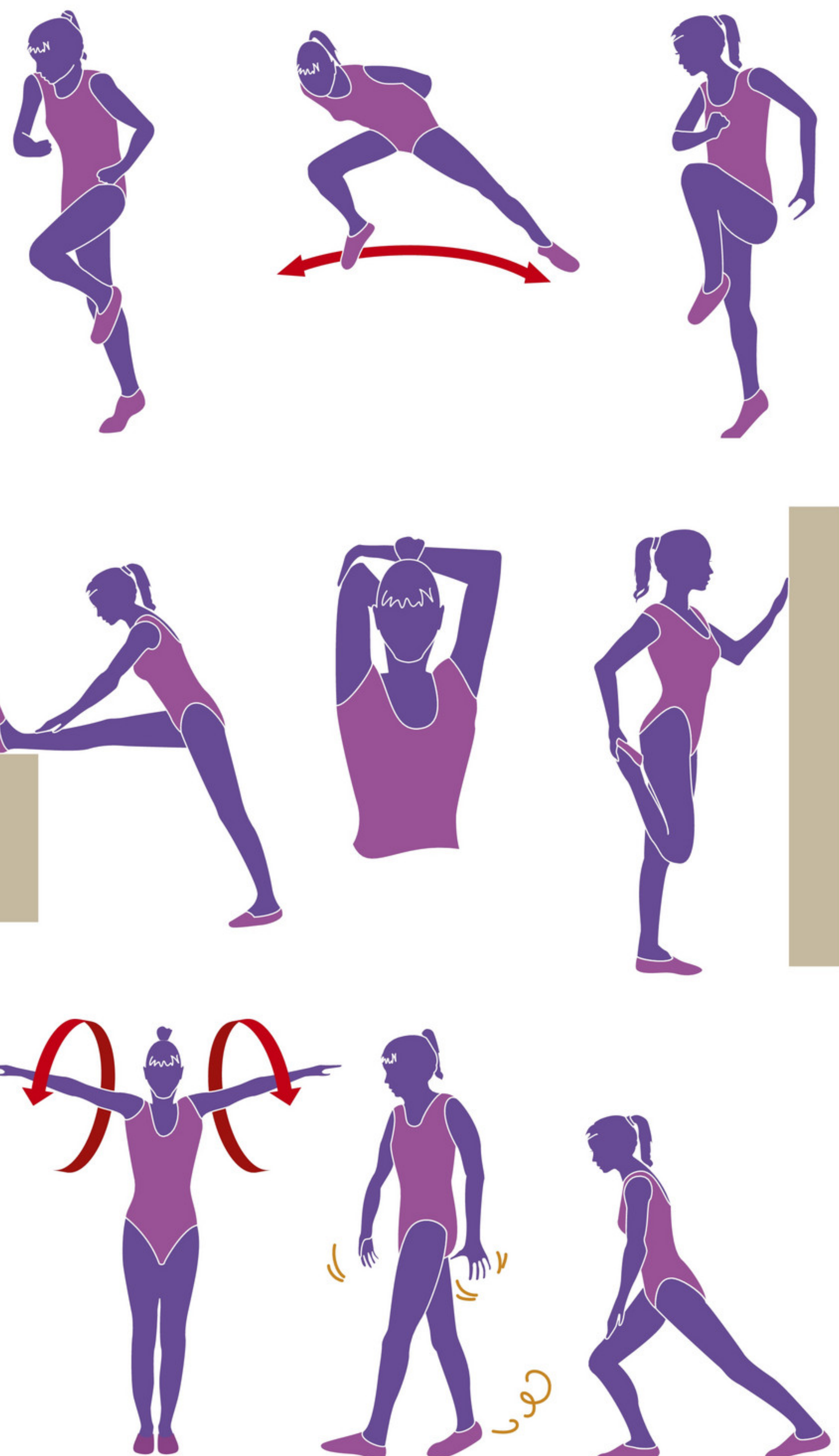
Muscles that suddenly have to work hard can get injuries such as muscle strains. This is why you should warm up before a match or training session. The warm-up gets more blood to the muscles, raising their temperature and carrying more oxygen to them. A warm-up does not have to take very long. Ten minutes can be plenty. And there should not be too much time between the warm-up and the match or training session, of course. This means that you should warm up again after a long interruption, particularly when the weather is cold!

STRETCHING

After the warm-up, you can do a few stretching exercises. Which stretches you should do depends on the sport. The stretches prepare your muscles for the work that they are going to have to do. Good stretching exercises will stretch your muscles gently and gradually. This makes them more flexible. When you do stretches, you move until you can feel a little bit of tension in the muscle, but not so much that it hurts. You should not try to bounce into a stretch exercise; that actually increases the risk of an injury.

COOLING DOWN

You use your muscles a great deal during sports or training sessions. This makes waste compounds accumulate in your muscles. After you have finished the session, your blood will start flowing more slowly and so the waste products will remain in your muscles for longer. These waste products are toxic and they can cause sore muscles. The cooling down keeps the blood flowing through your muscles a bit more quickly, which lets it transport more of the waste compounds away from your muscles. This makes it less likely that you will get sore muscles. A cool-down is in fact the reverse of the warm-up. You start with exercises that are a bit more intense and then take it more and more gently. You can do a few stretching exercises too. It is then a good idea to have a warm shower (but not too hot). A warm shower also helps keep the blood flowing through the muscles.

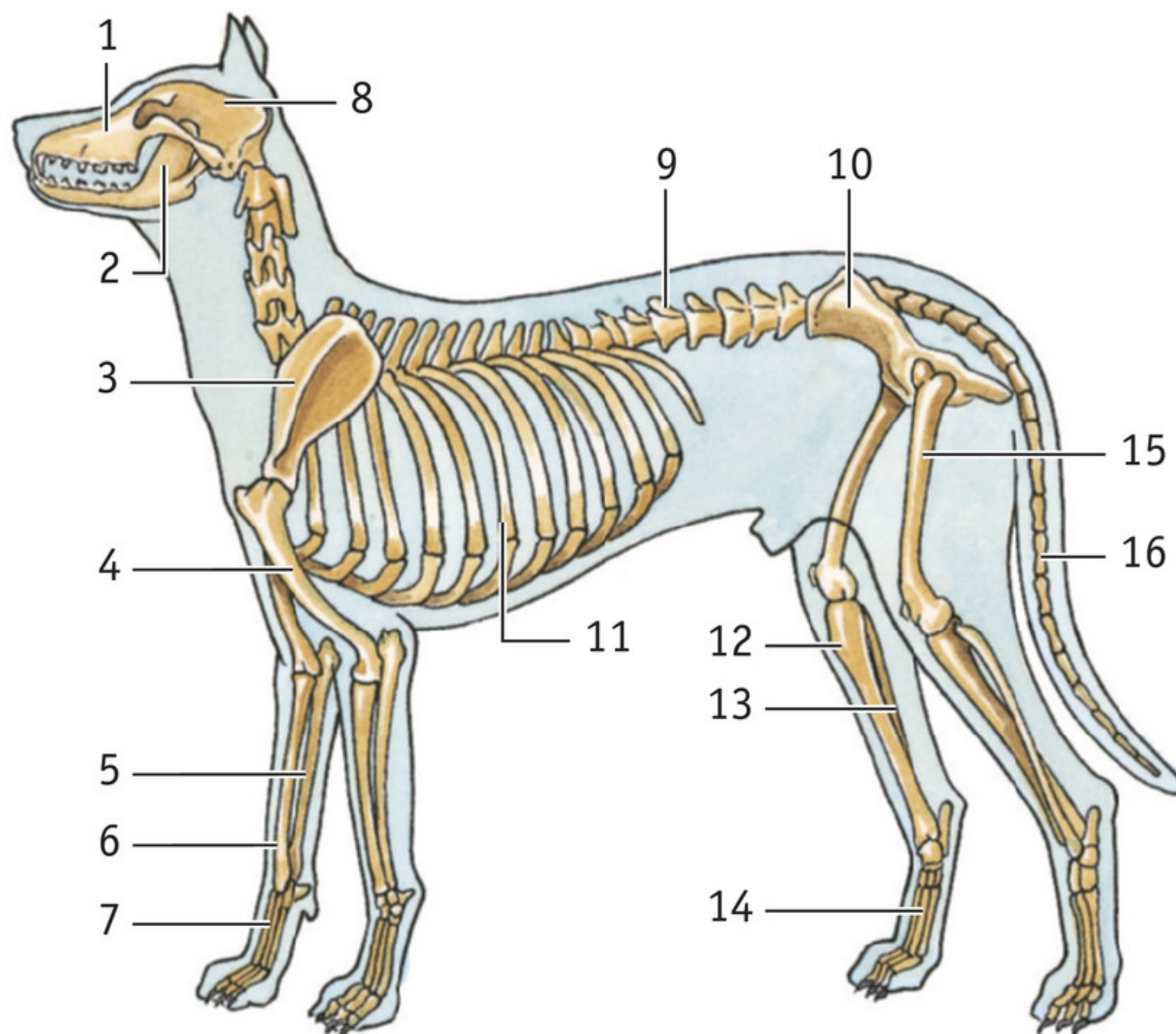


8 Skeletons of various mammals

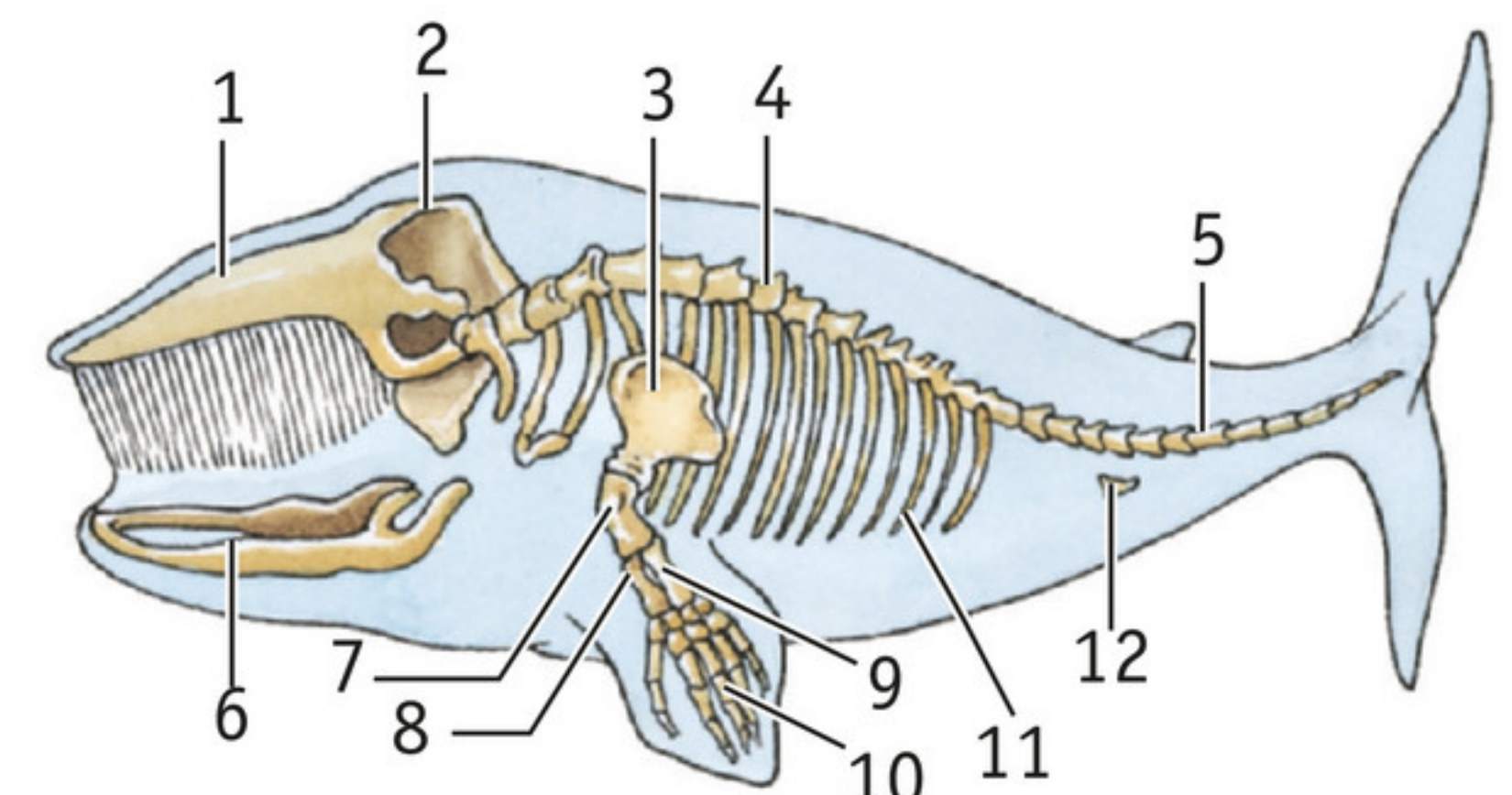
A taxidermist has to build the skeletons of all kinds of different animals. Even if you only take the mammals, there are more than five thousand different species. You don't have to know all the species to be able to tell what bones they are, because mammal skeletons all have a lot of similarities. The differences can be discovered by taking a good look at the skeletons; they are related to differences in the way the animals live. Figure 41 shows you the skeletons of a dog, a whale, a mole, a bat and a chimpanzee. You are going to compare those skeletons to one another. If there are skeletons of some of these animals at your school, you can use those.

WB EXERCISES 32 AND 33, PAGE 31

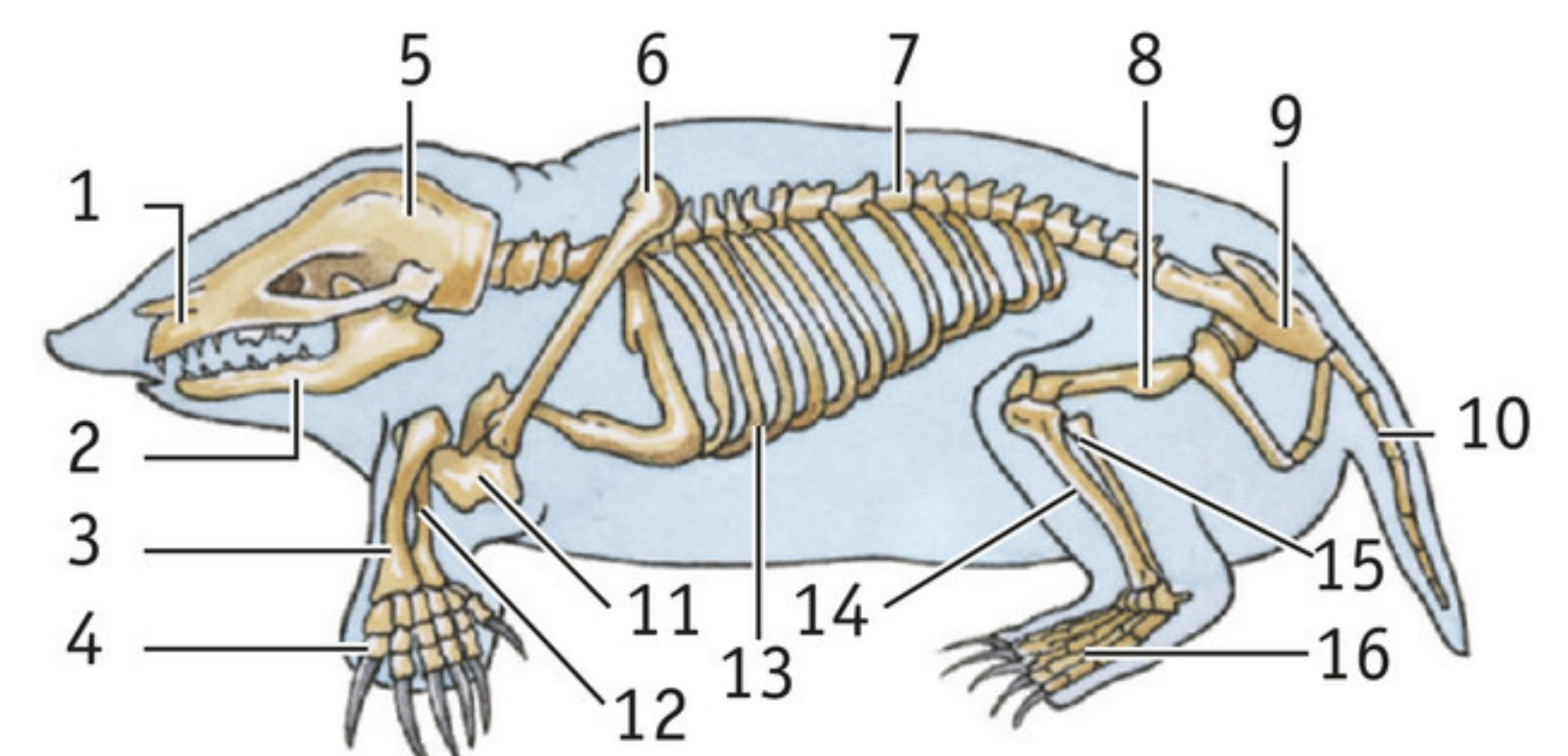
▼ Fig. 41



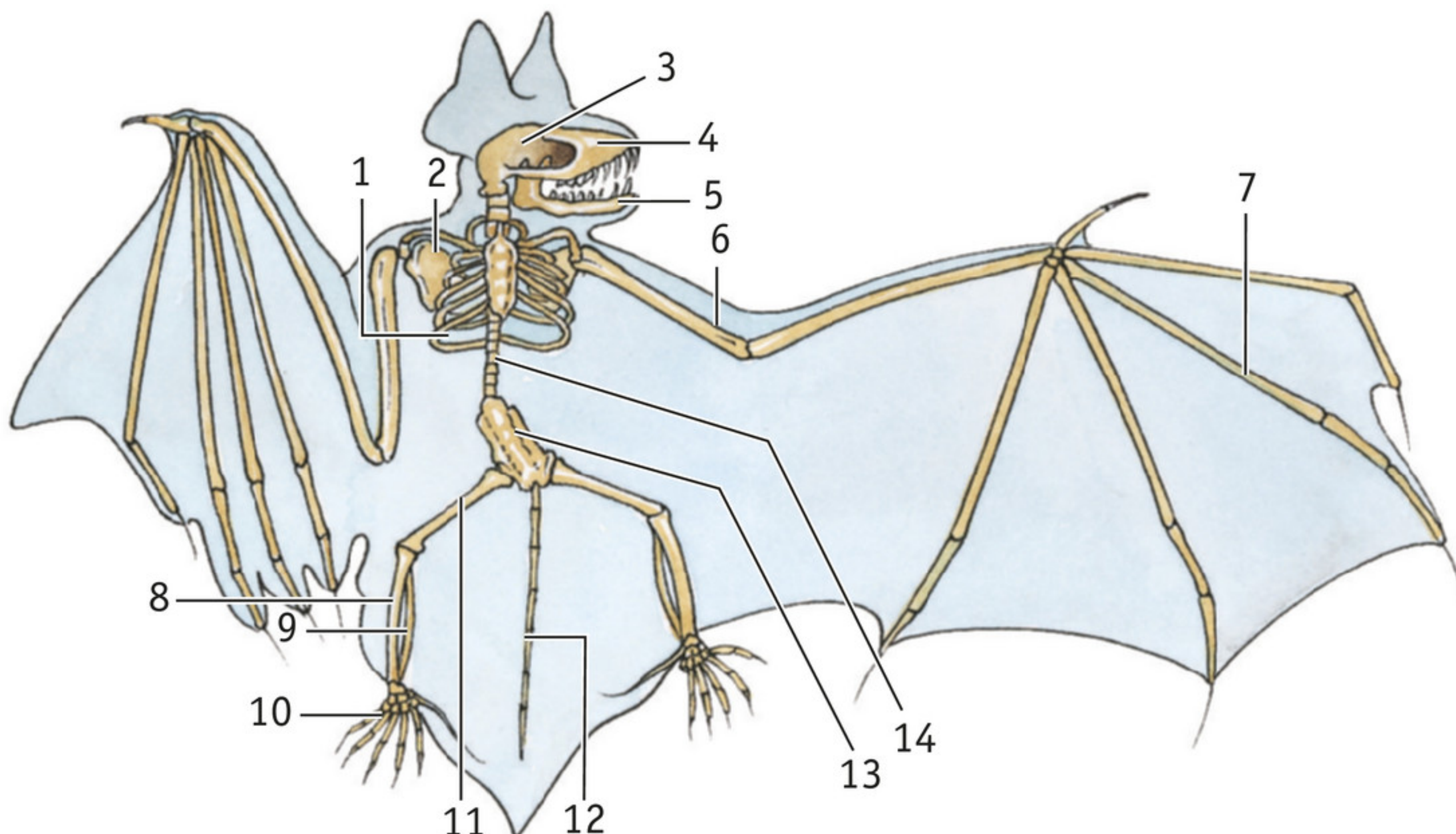
1 dog



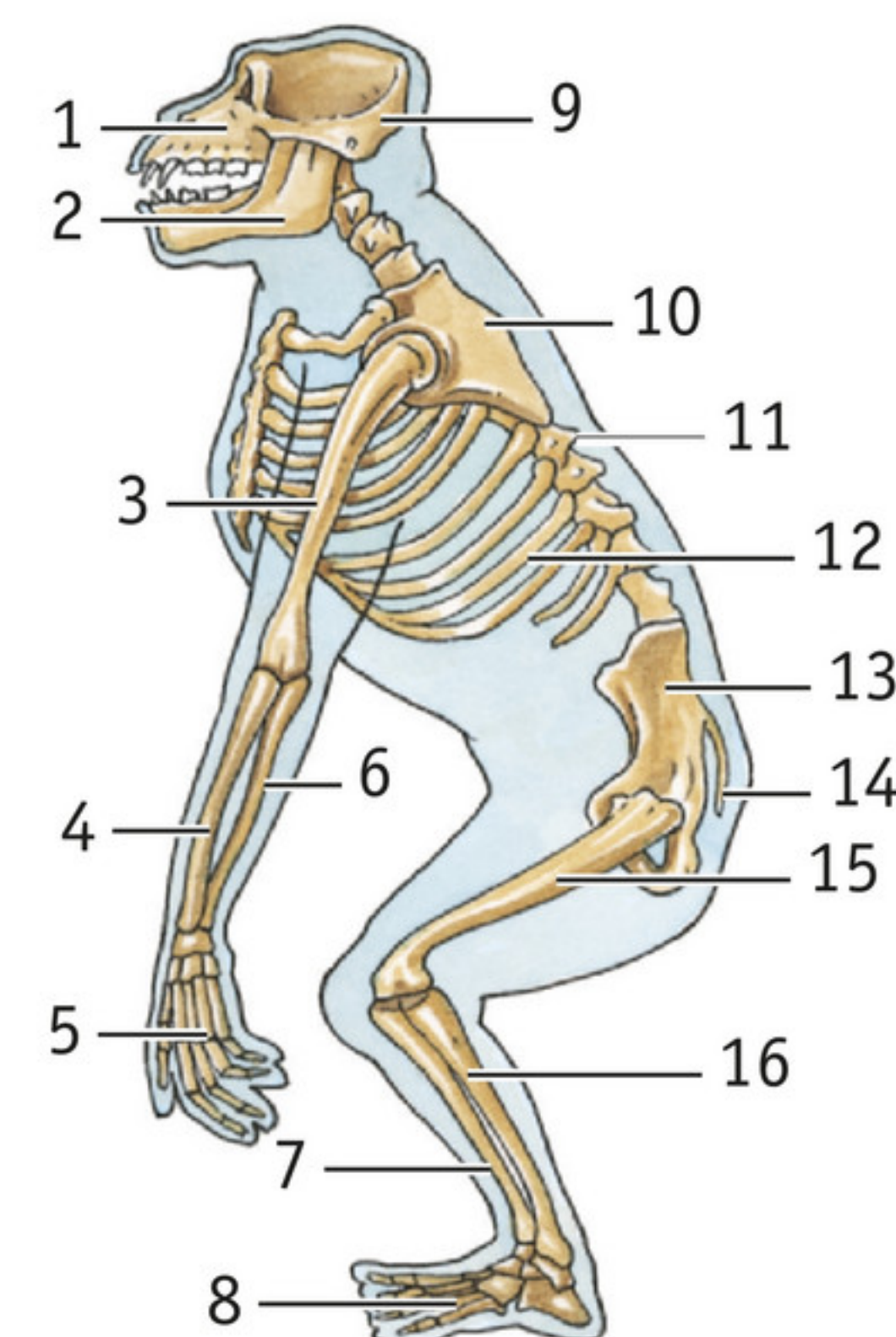
2 whale



3 mole



4 bat

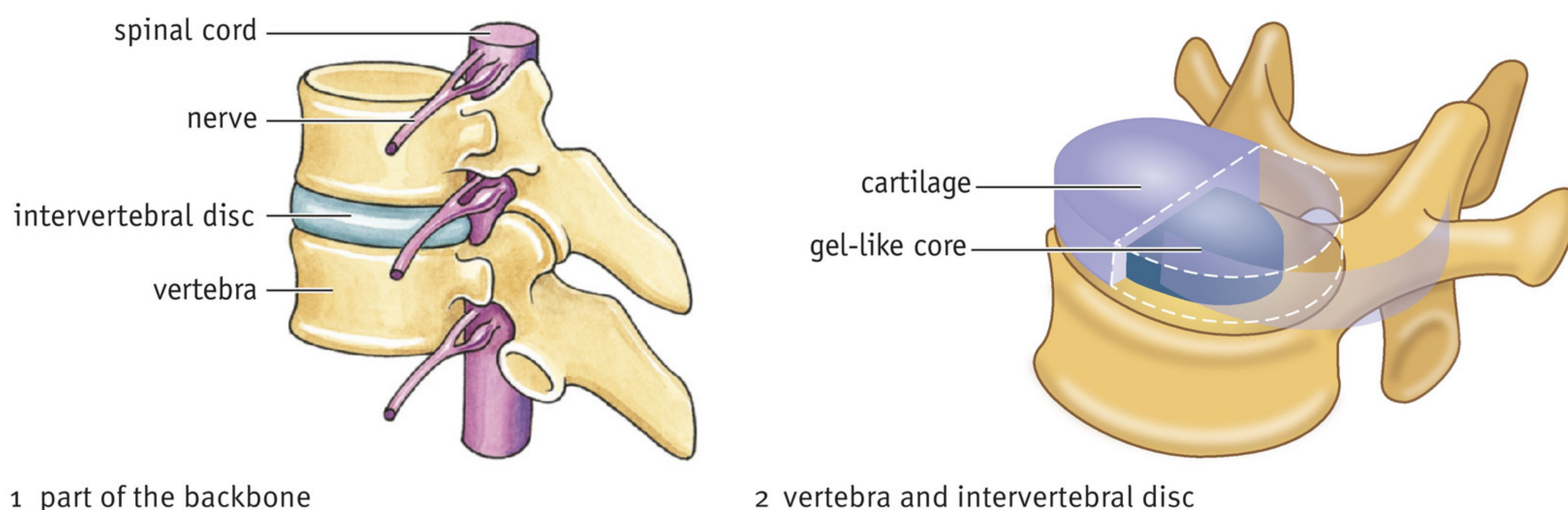


5 chimpanzee

9 Problems with the spinal column

You learned earlier that the vertebrae are connected together by the intervertebral discs between them. Intervertebral discs are a little bit elastic, letting them absorb shocks and allowing the backbone to bend. An intervertebral disc consists of a **gel-like core** that is surrounded by cartilage (see figure 42). The gel-like core is what gives an intervertebral disc its springiness. The fluid in this jelly-like centre is under high pressure.

▼ Fig. 42



SLIPPED DISC

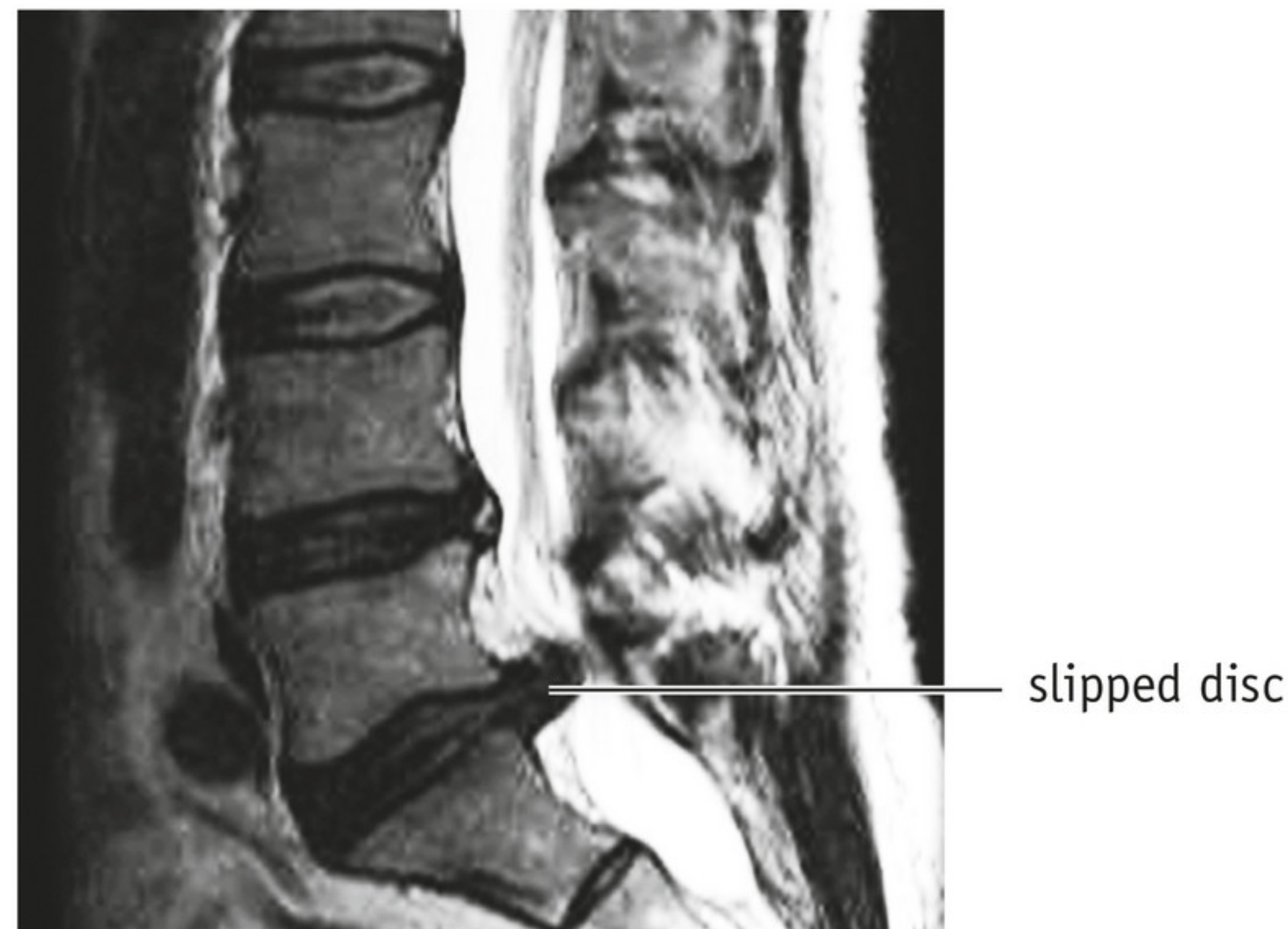
As you get older, the cartilage in the intervertebral discs becomes less stiff. Weak spots can then occur in the cartilage. The internal pressure can make the gel-like core bulge outwards. This is known as a **herniated** or **slipped disc**. Figure 43 shows you an X-ray of the spine of someone with a slipped disc. The protruding part of the intervertebral disc presses against the spinal cord, pinching some nerves. This can cause sharp pains in the back, buttocks or legs. Sometimes it can be so severe that the person may not be able to move the leg anymore.

A slipped disc can recover spontaneously. A lot of people think that they must move their back as little as possible if they have a slipped disc. This is incorrect. Movement can in fact help, but you mustn't overdo it and should rest in between. Staying in bed makes the muscles stiffer and you will become less fit.

If a nerve is severely pinched, an operation may be needed. The surgeon then removes the protruding part, or the entire intervertebral disc.

Why some people get slipped discs and others do not is not known exactly, but it seems very likely that posture (sitting a lot) and a lack of healthy exercise can play a role.

► **Fig. 43** Slipped disc (X-ray).



LUMBAGO

Sometimes a slipped disc can be confused with **lumbago**. Lumbago often occurs suddenly after an awkward movement. This causes muscle spasms in the lower back, which in turn causes back pain that can make it difficult for someone to stand up. The pain can last for a few days or sometimes a couple of weeks. The best thing is to keep moving; that gets rid of the spasms most quickly. It is not a good idea to lift heavy objects, sit in a single position for a long time or be on your feet for too long. Keeping the back warm can be helpful too.

Obesity, incorrect posture and lack of exercise increase the risk of lumbago.

WB EXERCISES 34 AND 35, PAGE 32

Summary

OBJECTIVE 1

You must be able to recognise and name the bones of the skeleton in a drawing.

- The skull.
 - Bones of the skull: frontal bone, parietal bones, occipital bone, temporal bones, sphenoid bones, cheekbones, nasal bones, upper jaw, lower jaw.
- The torso.
 - Spinal column: cervical, thoracic and lumbar vertebrae, sacrum, coccyx.
 - Ribcage: thoracic vertebrae, ribs, thighbone.
 - Pectoral girdle: shoulderblades, collarbones.
 - Pelvic girdle: pelvis, sacrum.
- The limbs (arms and legs).
 - Arm: humerus, ulna, radius, carpals, metacarpals, phalanges.
 - Leg: thighbone, kneecap, tibia, fibula, tarsals, metatarsals, phalanges.

OBJECTIVE 2

You must be able to list the functions of the skeleton and describe the relationship between the shape and function of bones.

- The skeleton lets you stand upright.
- The skeleton protects fragile organs.
- The skeleton makes movement possible.
 - Most bones in the skeleton are connected together in ways that let them move.
 - Bones have protrusions that muscles are attached to.
- The skeleton gives the body its shape.
 - A streamlined body shape lets an animal move quickly, e.g. in water.
 - The shape of an animal's legs depend on how the animal moves. Plantigrades: walk on the whole of the sole of the foot, e.g. bears, humans. Digitigrades: walk on the toes, e.g. cats. Unguligrades (hoofed animals): walk on the tips of the toes, e.g. horses.

OBJECTIVE 3

You must be able to describe the structure of bones and you must be able to describe how the composition of bones changes during the course of your life.

- The skeleton consists of long bones and flat bones.
 - Long bones: long bones, such as the ulna and thighbone.
 - Flat bones include the bones of the skull and the pelvis.

- Cartilage is firm but very flexible.
 - In adults, cartilage tissue is found e.g. in the end of the nose, the ears, in joints and between the vertebrae.
 - Cartilage cells are found in groups together in the extracellular material.
- Bone is very sturdy and a little bit flexible.
 - Calcium phosphate in the extracellular material provides the firmness (rigidity). Calcium phosphate dissolves in hydrochloric acid.
 - Collagen in the extracellular material provides flexibility. Collagen burns in a flame.
 - Bone cells are arranged in the extracellular material in rings around small canals.
- Composition of the bones during your life.
 - Babies: the bones consist primarily of cartilage tissue.
 - As they get older, the cartilage tissue changes to bone tissue.
At first, there are still gaps between the bones of the skull, known as the fontanelles.
 - Children: the bones consist of bone tissue with a large amount of collagen and not much calcium phosphate.
 - The elderly: the bones consist of bone tissue with relatively little collagen and a lot of calcium phosphate.

OBJECTIVE 4

You must be able to distinguish between the four ways in which bones are connected together.

- Some bones are connected together in ways that do not let them move.
 - Fused: two or more bones have grown together to become one.
Example: the vertebrae of the sacrum.
 - Sutured.
Example: the bones of the skull.
- Some bones are connected together in ways that let them move.
 - By cartilage, allowing a small amount of movement.
Examples: between the ribs and the sternum, between the vertebrae.
 - By a synovial joint, allowing a large amount of movement.
Examples: the phalanges of the fingers, the pelvis and the thighbone.

OBJECTIVE 5

You must be able to describe how synovial joints work.

- In a synovial joint, the ball-shaped bone rotates in the socket bone.
 - Layers of cartilage prevent wear and tear and make the movements smoother.
 - The joint capsule secretes synovial fluid, allowing the joint to move smoothly.
 - The joint's ligaments and capsule hold the bones in place.
- The synovial joint is constructed in a way that allows the bones to move in a specific manner.
 - Ball-and-socket joints: a rotational movement is possible (shoulder joint and hip joint).
 - Hinge joints: only a back-and-forth motion is possible (between finger or toe phalanges, between the humerus and the ulna, and between the thighbone and the tibia).
 - Pivot joint: one bone rotates along its lengthwise axis around the other (radius and ulna).

OBJECTIVE 6

You must be able to describe how muscles work.

- Skeletal muscles are attached to the bones by tendons.
 - Attachment site: the place where a tendon is attached to the bone.
 - Tendons cannot contract.
- Muscles can move a bone by contracting.
 - When a muscle contracts, it becomes shorter and thicker.
- Antagonistic muscle pairs: two muscles that work together to move a bone back and forth in a particular direction.
 - When antagonistic muscles contract, they have opposite effects.
Example: the arm flexor and extensor muscles (biceps and triceps).

OBJECTIVE 7

You must be able to state why good body posture is important.

- The backbone has a double-S shape.
 - The shape is maintained by the back muscles that are connected to the vertebrae.
 - Intervertebral discs act as shock absorbers.
- Good body posture prevents abnormalities in the shape of the spinal column and so helps avoid pain in the back and elsewhere.
 - Adopting the wrong posture too often can lead to abnormalities in the shape of the backbone.

- Good posture helps the backbone maintain the double-S shape and reduces the risk of back complaints.
- It is important that the backbone keeps its double-S shape during lifting. Stick to the rules for lifting properly as far as possible.
- Regular exercise and sport strengthen the back muscles. This will make you less likely to suffer from back pain.

OBJECTIVE 8

You must be able to explain what the problem is in a number of sporting injuries and say how they can be treated.

- Multiple factors are often involved in sports injuries.
 - For example: rough play, poor training, lack of fitness, overexertion, fatigue, poor equipment and poor warming up and cooling down (or none at all).
- Muscle strain.
 - Cause: overexertion or a sudden movement.
 - A muscle strain will recover with rest.
- Broken bone.
 - Cause: usually either a fall or rough (foul) play.
 - For the bone to heal, the two halves must be held in place. Sometimes the halves of the bone have to be set.
- Runner's knee: a meniscus in the knee joint is damaged.
 - Cause: e.g. a rotation of the body while the lower leg stays in place.
 - A damaged meniscus often requires surgical treatment.
- Bruises (contusions): damage to tissue without anything being torn or broken.
 - Cause: usually the result of a knock, blow or kick.
 - A bruised area swells up; internal bleeding is one of the reasons why.
 - A contusion will generally recover with rest.
 - Sprain: a bruise to a joint.
- Dislocation: the ball-shaped bone comes out of its place in the socket bone.
 - A doctor then has to put the ball end of one bone back in place in the socket of the other.
- Inflammation of the attachment sites of muscles.
 - Cause: overuse of muscles.
 - In tennis elbow, the attachment site of a muscle in the elbow is inflamed.
 - Inflammation generally recovers with rest.

- RSI occurs when the same movement is made repeatedly.
 - Good sitting posture and a good workplace help prevent RSI.
- Many injuries are treated by cooling down the affected area.
 - Cooling reduces internal bleeding.
 - Cooling reduces the swelling.
 - Cooling reduces the pain.

EXTRA OBJECTIVE 9

You must be able to list the differences in drawings of animal skeletons compared to the human skeleton, and you must be able to name the bones.

- There are a lot of similarities between the skeletons of humans and other mammals.
- Certain bones are often missing in the skeletons of many mammals, e.g. the kneecap.

EXTRA OBJECTIVE 10

You must be able to describe what the problem is in a slipped disc and in lumbago.

- An intervertebral disc is made of cartilage with a gel-like centre.
 - This gel-like core gives the intervertebral disc its springiness.
- Slipped disc: a break in the cartilage of an intervertebral disc.
 - The gel-like core can press up against a nerve, causing back pain that radiates to the legs.
- Lumbago: spasms of the muscles in the lower back.
 - Lumbago generally occurs suddenly after an awkward movement.
 - The back pain does not radiate out towards the legs.
 - Poor posture, obesity and too much sitting increase the risk of lumbago.

SKILLS AND COMPETENCIES**BASICS**

- You have practised getting information from texts.
- You have practised using the microscope.
- You have practised making drawings.
- You have practised doing an investigation.
- You have learned the importance of good posture and healthy sporting activities.

The diagnostic test does not include any questions about these skills and competencies.

You have met a taxidermist and a physiotherapist in this unit. You have also seen applications in science and daily practice that use the material from this unit.

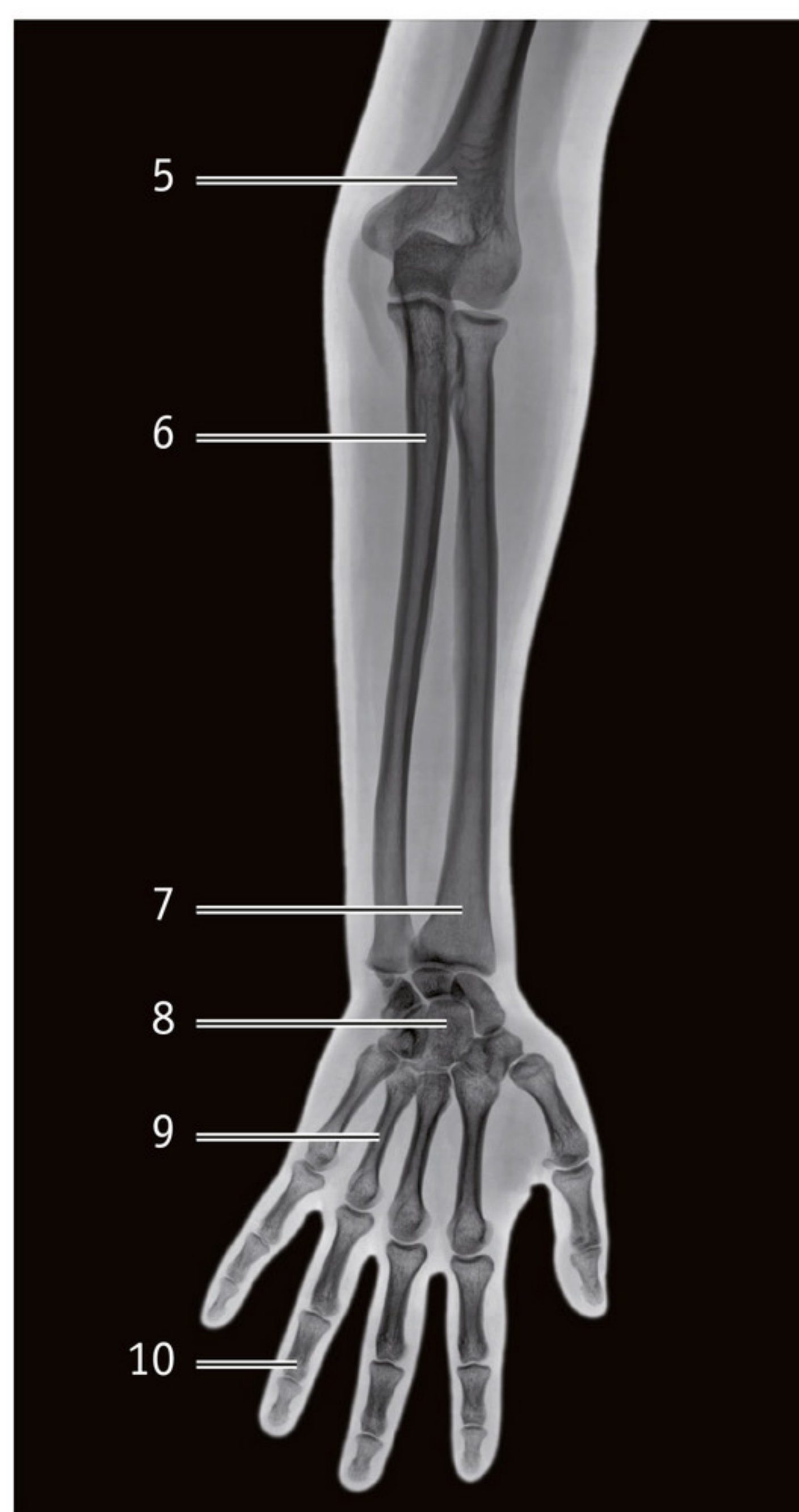
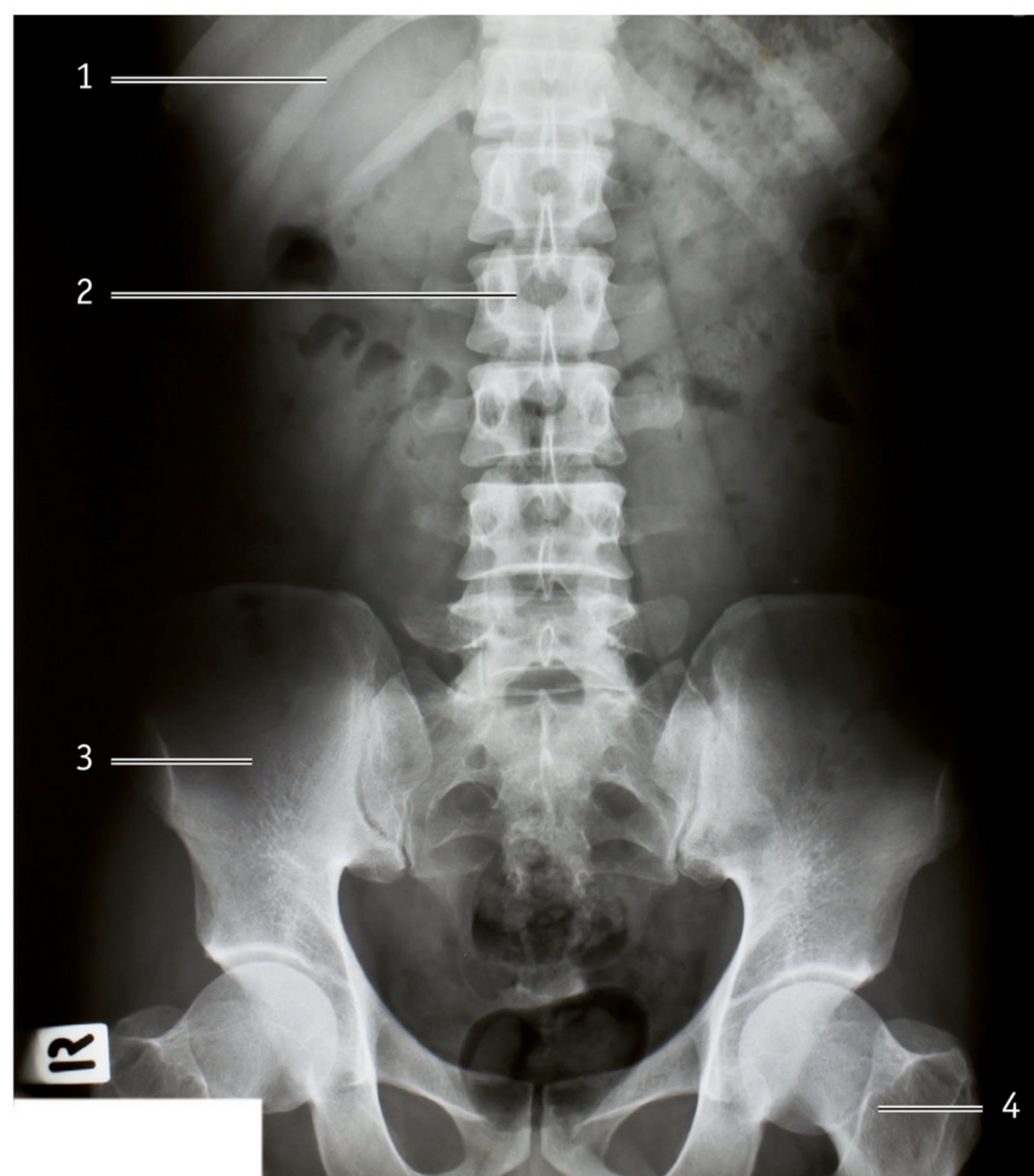
Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

To visualise the bones of the skeleton, hospital specialists often make X-rays. Figure 44 shows three X-rays. Write down the names of the numbered bones.

▼ Fig. 44



OBJECTIVE 2

Answer the following questions.

- 1 Your skeleton lets you stand upright. Write down three other functions of the human skeleton.
- 2 Figure 45 shows you the vertebrae of a whale. One part of it is labelled with the letter P. Which function of the skeleton does part P play a role in?

▼ Fig. 45



- 3 Babies who have learned to stand up often have rather bandy legs. Which function of these babies' skeletons is not yet fully developed?
- 4 What is the term for a body shape that is suitable for moving quickly in water? Animals may walk on their whole foot, on their toes or on the tips of their toes.
- 5 What is the name for animals that walk using the entire foot?
- 6 What do you call animals that walk on the tips of their toes?
- 7 Which group does the animal shown in figure 46 belong to?

▼ Fig. 46

**OBJECTIVE 3**

Answer the following questions.

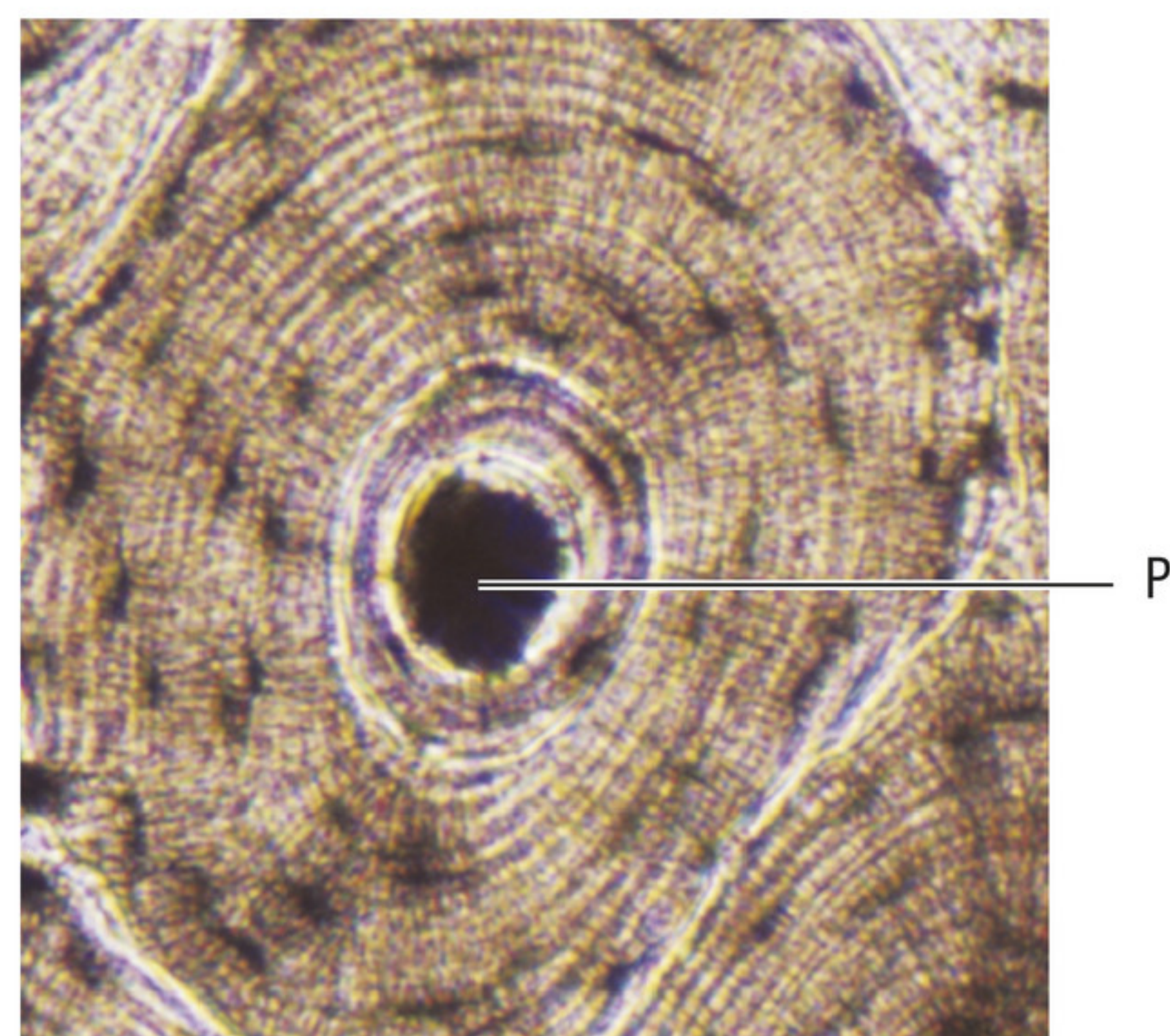
- 1 What do the bones of newborn babies mainly consist of?
- 2 What component of the extracellular material gives bone tissue its rigidity (hardness)?
- 3 Figure 47 shows a biology teacher demonstrating a chicken bone that has had a certain treatment. What kind of treatment has this bone had?

▼ Fig. 47



Figure 48 shows a microscope photo of a piece of human tissue.

▼ Fig. 48



- 4 What type of tissue is shown in the photo?
- 5 What does letter P in figure 48 indicate?
- 6 In X-ray photographs of bones, the parts containing more calcium phosphate are whiter. Figure 49 shows two X-rays of hands (the photographs are not to the same scale).
Which of the two photographs is of a child's hand? Explain your answer.

▼ Fig. 49



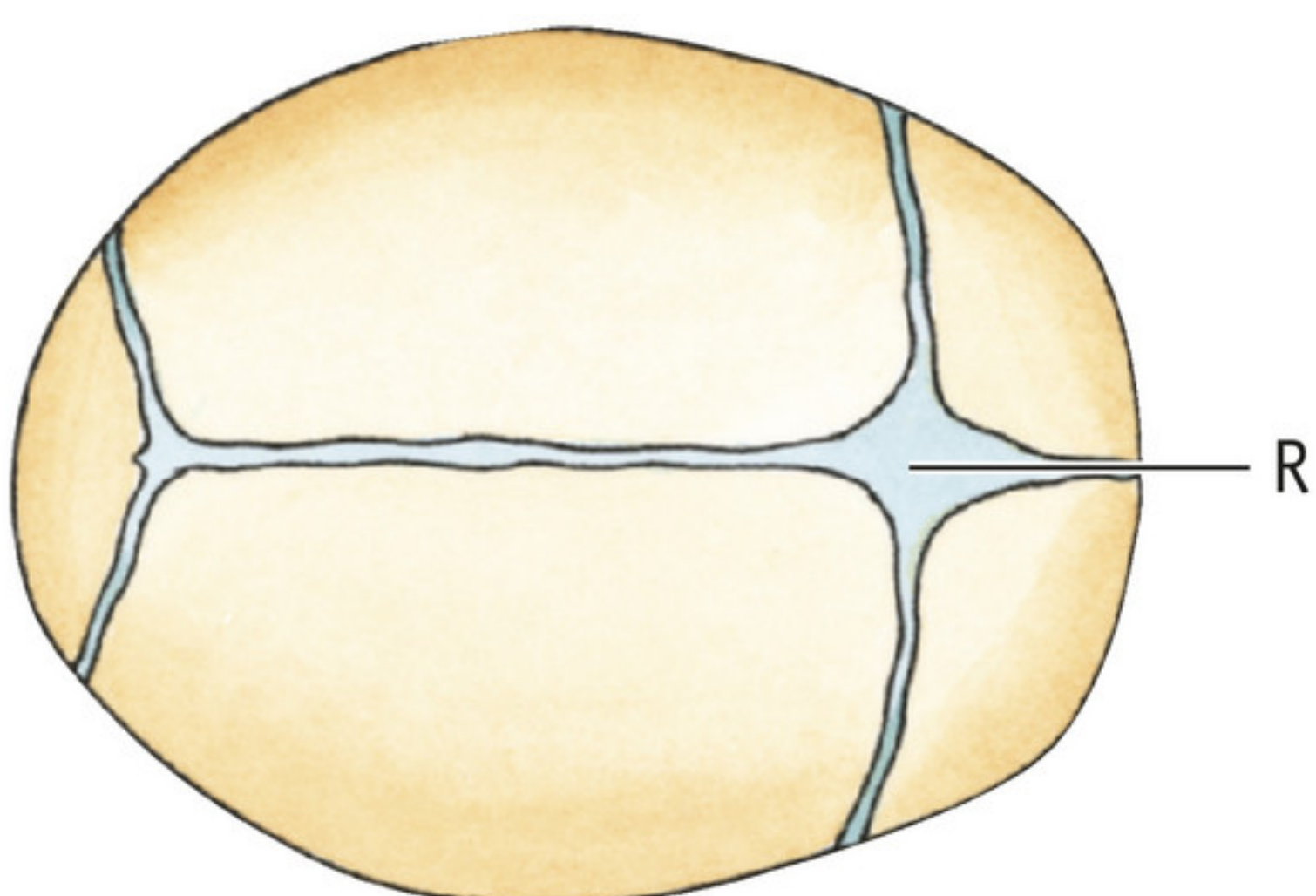
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2

- 7 Figure 50 is a schematic drawing of the skull of a newborn baby, seen from above. What is the name of the part labelled R?

▼ Fig. 50



OBJECTIVE 4

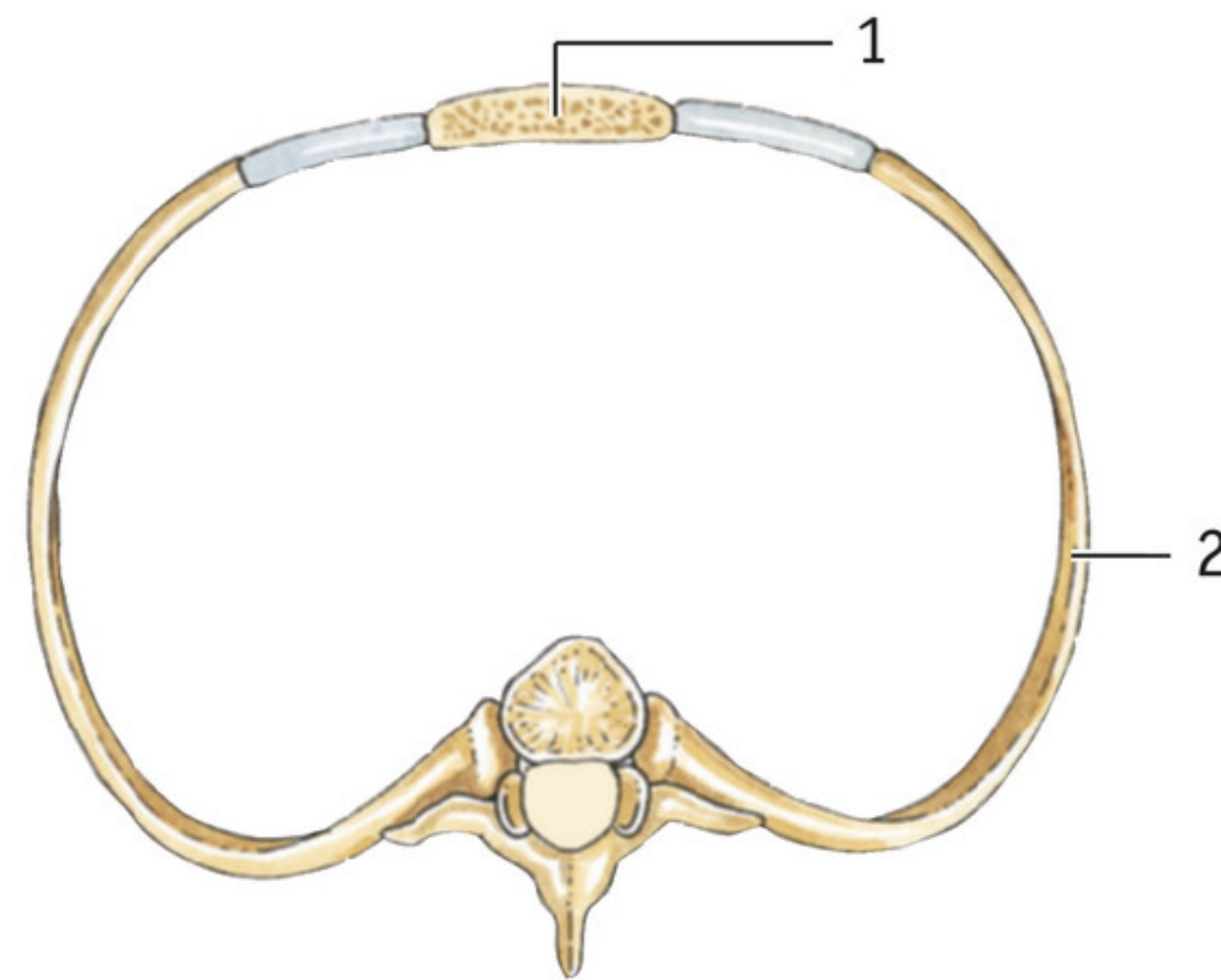
The scoresheet shows a table listing the four ways that bones can be connected together. Answer the following questions by placing crosses in the correct columns.

- 1 In what type of joint have two or more bones become a single one?
- 2 In which two types of joint is motion not possible?

Figure 51 is a diagram of part of a human skeleton.

- 3 What type of connection is there between parts 1 and 2 in the drawing?
- 4 What other type of connection is there in this part of the skeleton?

▼ Fig. 51



- 5 Figure 52 shows part of the skull of a dog. What type of joint is marked in the drawing with the letter R?
- 6 How is the lower jaw connected to the rest of the skull?

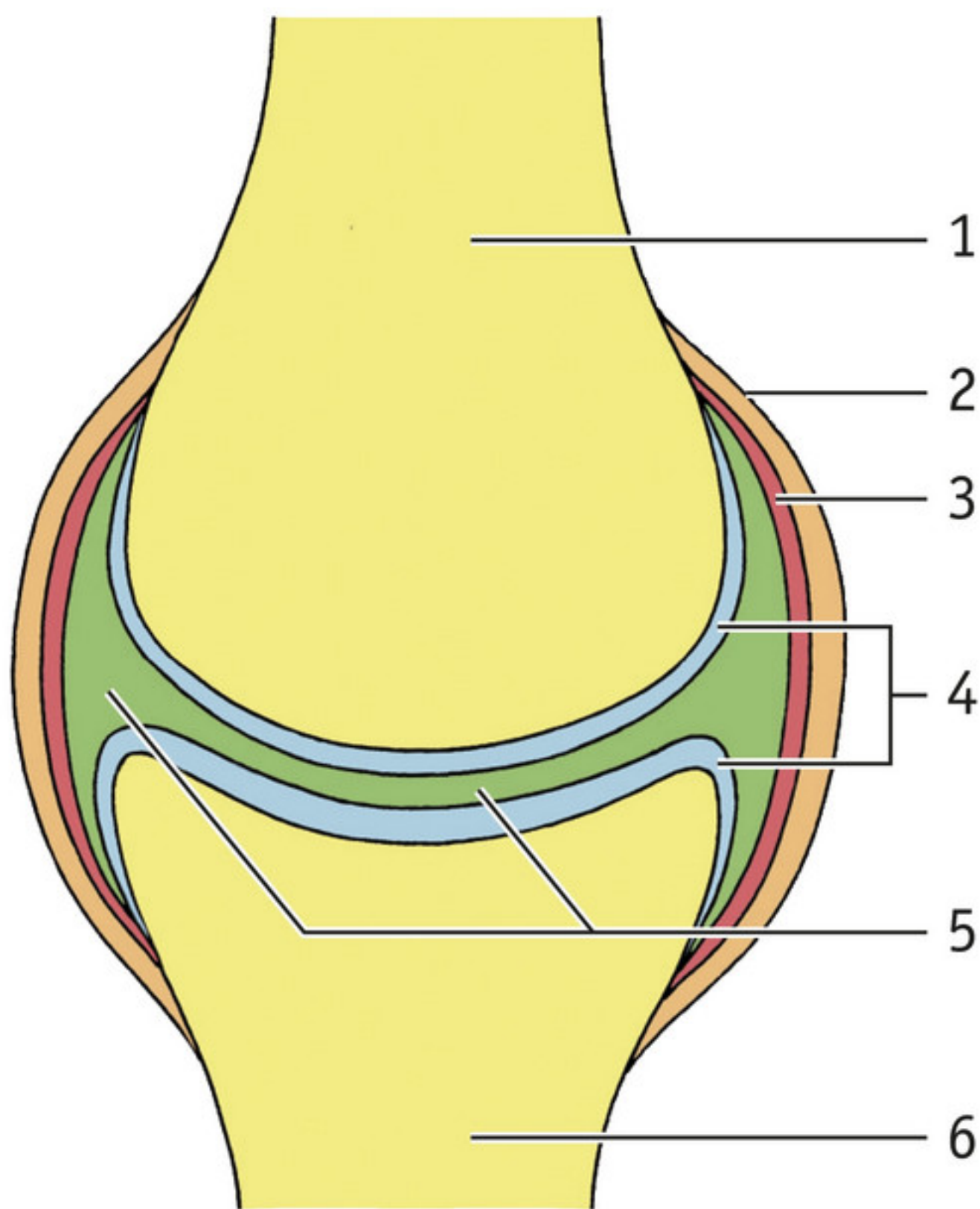
▼ Fig. 52



OBJECTIVE 5

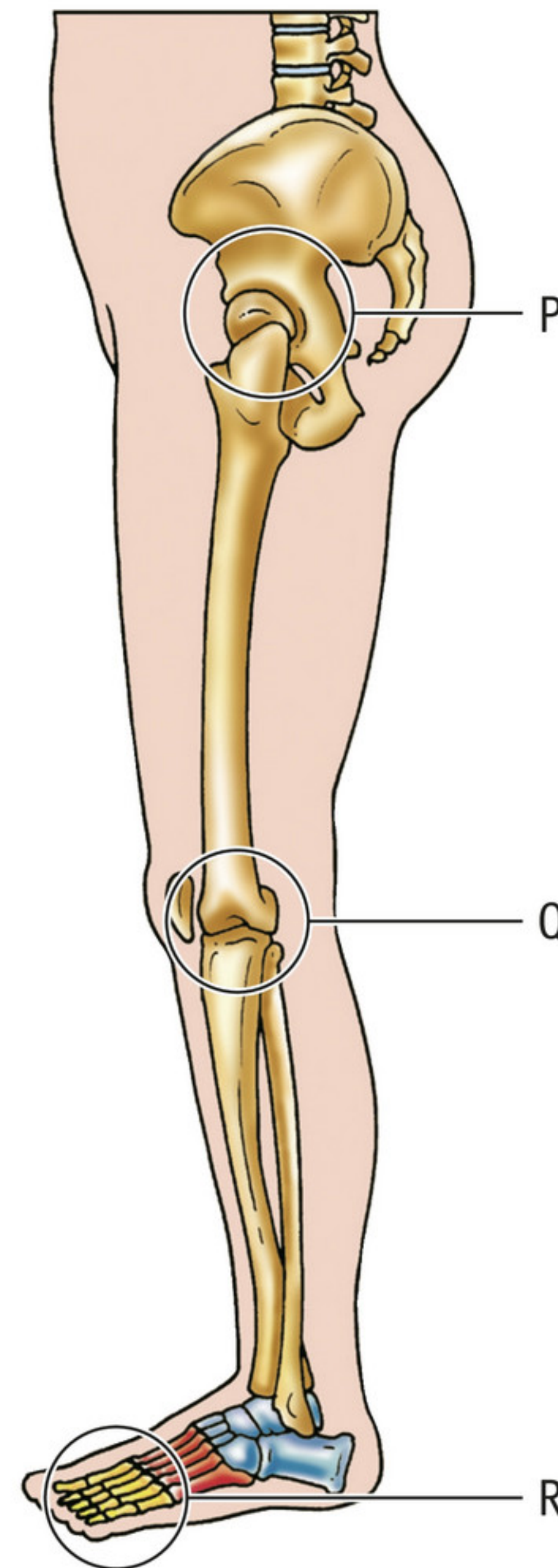
Answer the following multiple choice questions.
Figure 53 is a schematic drawing of a synovial joint.
Questions 1 and 2 are about this figure.

▼ Fig. 53



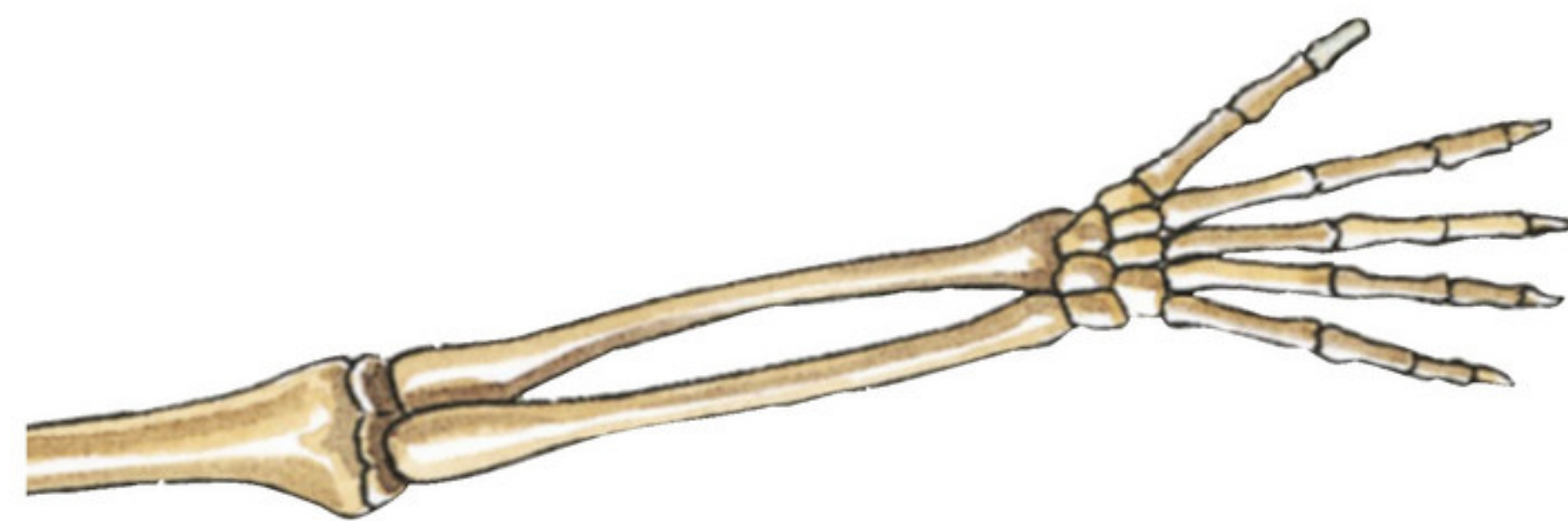
- 1 Which of the numbered parts is the joint capsule?
 A 2.
 B 3.
 C 4.
 D 5.
- 2 Which of the numbered parts are for letting the bones move smoothly against each other?
 A 1 and 6.
 B 2 and 3.
 C 3 and 5.
 D 4 and 5.
- 3 Figure 54 shows a human leg. Three joints are labelled in the drawing with letters P, Q and R. Which of the letters indicates a hinge joint?
 A Only Q.
 B Only R.
 C Only Q and R.
 D P, Q and R.

▼ Fig. 54



- 4 Figure 55 is a drawing of part of a skeleton. Can you find a ball-and-socket joint in this part of the skeleton? And a pivot joint?
 A Neither a ball-and-socket joint nor a pivot joint.
 B A ball-and-socket joint, but no pivot joint.
 C A pivot joint, but no ball-and-socket joint.
 D Both a pivot joint and a ball-and-socket joint.

▼ Fig. 55

**OBJECTIVE 6**

Answer the following multiple choice questions.

- 1 A doctor is examining an arm injury. The doctor asks the patient to raise the hand while the doctor holds the hand down. Figure 56.1 shows you how the doctor is holding the arm for this examination. Figure 56.2 is a schematic diagram of part of an arm.

Muscle P is attached to the humerus by tendon Q. On the right-hand side (not shown in the picture), muscle P is connected to the hand. When muscle P contracts, the hand moves upwards.

Does muscle P become shorter or longer or stay the same length when the hand is moved upwards?

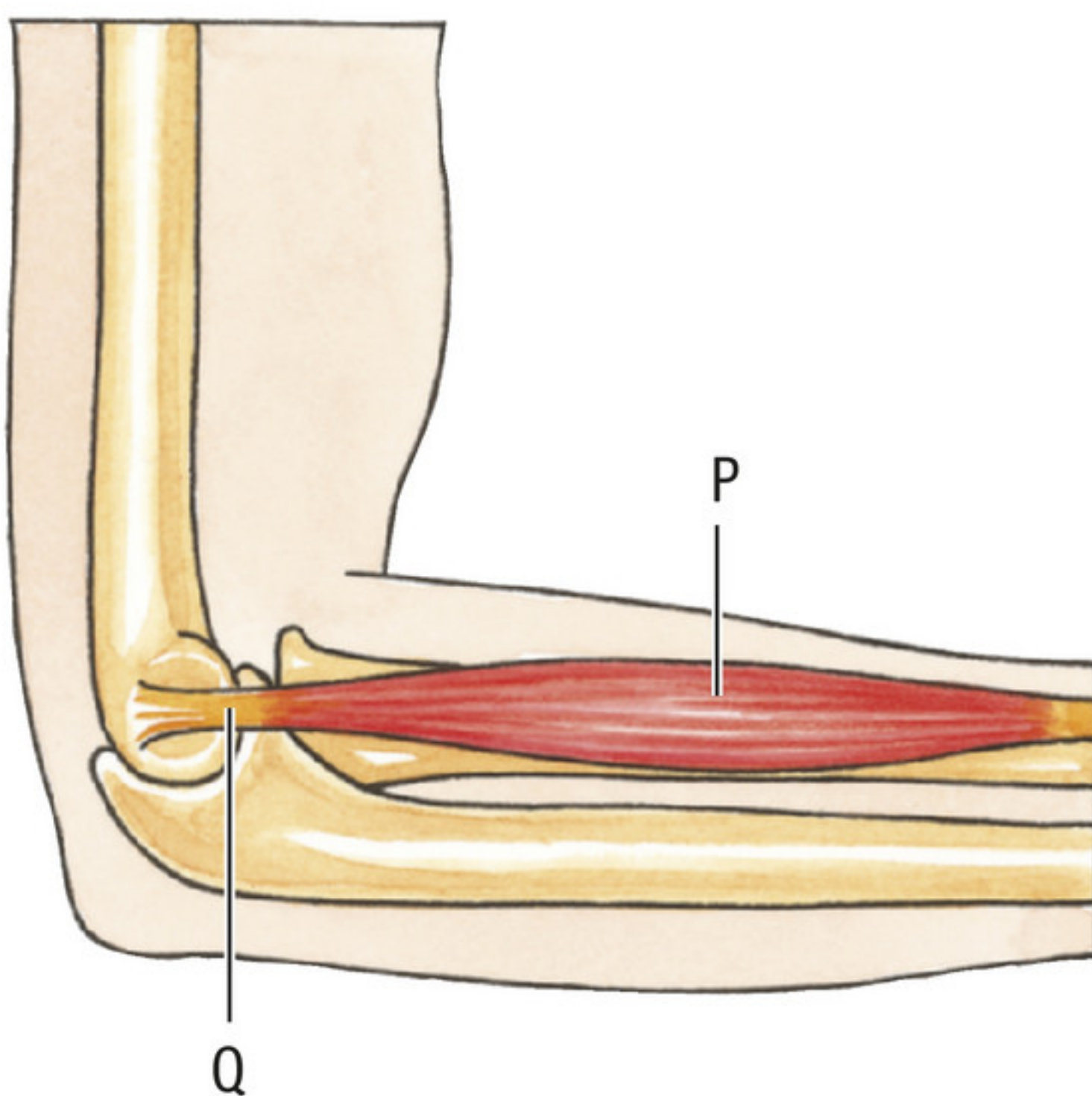
What about tendon Q?

- A** Muscle P and tendon Q both become shorter.
- B** Muscle P gets shorter, tendon Q stays the same length.
- C** Muscle P stays the same length, tendon Q gets shorter.
- D** Muscle P and tendon Q both stay the same length.

▼ Fig. 56



1



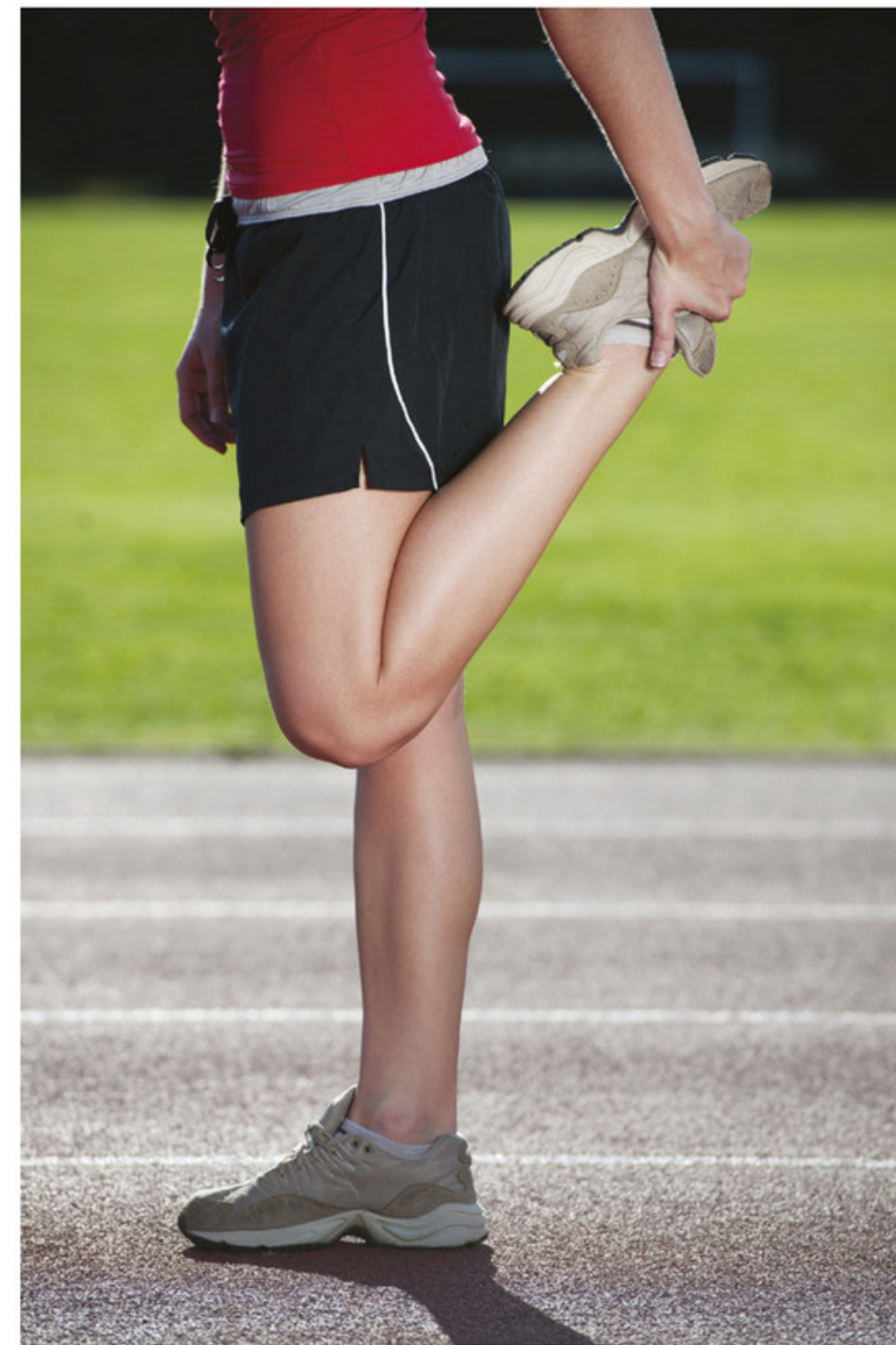
2

- 2** Figure 57 shows a pupil who is doing a stretching exercise.

Which muscle is being stretched in this exercise?

- A** The quadriceps.
- B** The calf muscle.
- C** The hamstring.
- D** The tibial muscle.

▼ Fig. 57



- 3** A biology teacher asks two pupils what antagonistic muscles are.

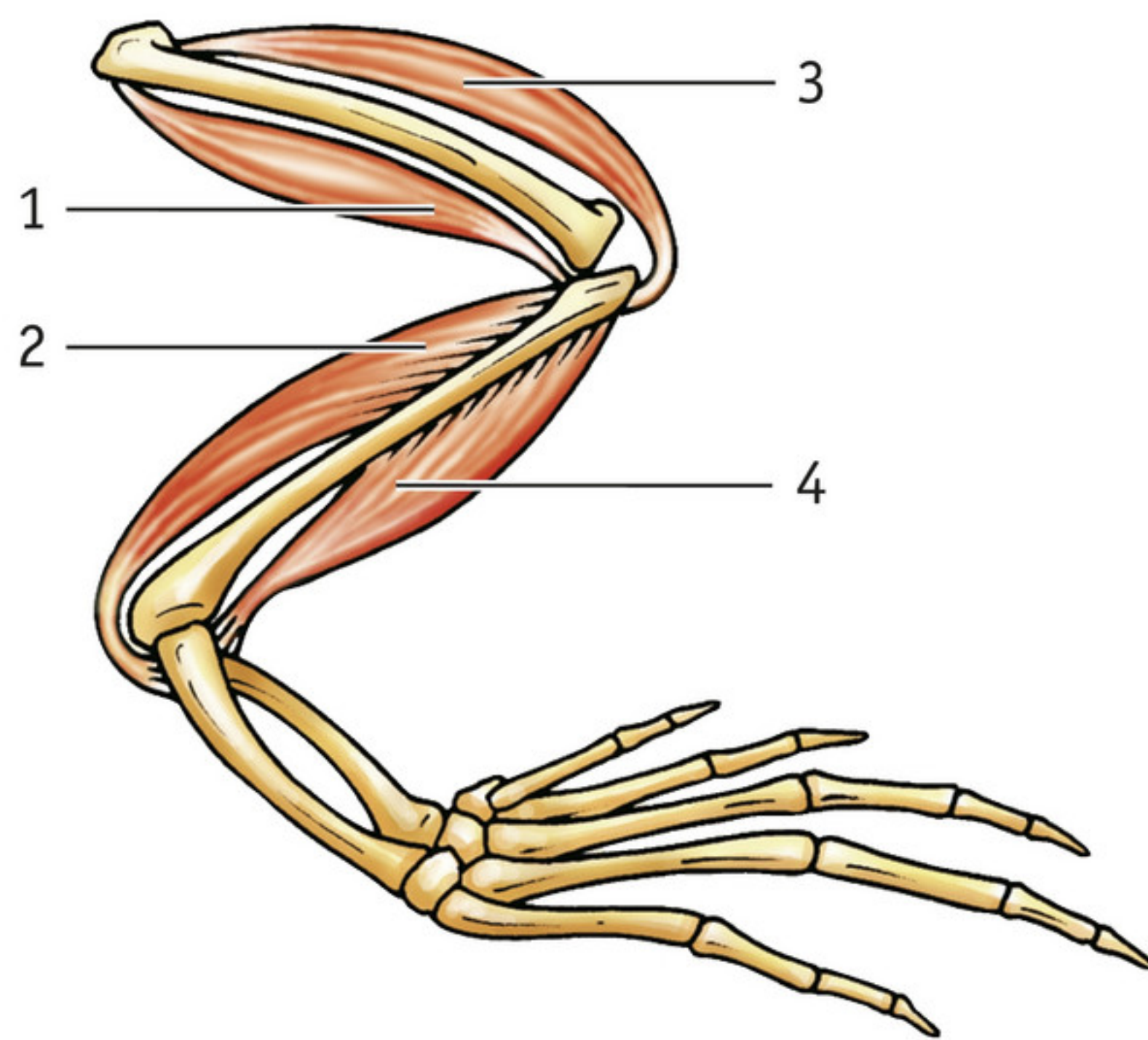
Roy says that antagonistic muscles are pairs of muscles that work against each other.

Sharon says that antagonistic muscles are pairs that have opposite effects when they contract. Who is right?

- A** Roy and Sharon are both right.
- B** Only Roy is right.
- C** Only Sharon is right.
- D** Neither of them is right.

The following information is for questions 4 and 5.
Figure 58 is a diagram showing the bones and a number of muscles in the hind leg of a frog.

▼ Fig. 58



- 4 A frog extends its hind legs to jump. Which two muscles are contracting?
- A Muscles 1 and 2.
 - B Muscles 1 and 4.
 - C Muscles 2 and 3.
 - D Muscles 2 and 4.
- 5 Which is an antagonistic muscle pair?
- A Muscles 1 and 2.
 - B Muscles 2 and 3.
 - C Muscles 2 and 4.
 - D Muscles 3 and 4.

OBJECTIVE 7

Answer the following questions.

Figure 59 shows you a pupil working with a computer at school.

- 1 What kind of complaints may he get if he regularly works in this posture?
- 2 What shape does the backbone have in a person with good posture?
- 3 What is the term for the cartilage that can be found between the vertebrae of the spinal column?
- 4 What are the two ways that your back can act as a shock absorber?

Figure 60 shows a man lifting a child.

- 5 Is the man sticking to the rules for safe lifting?
- 6 Might he suffer from back pain if he regularly lifts like this?

▼ Fig. 59



▼ Fig. 60



OBJECTIVE 8

Answer the following multiple choice questions.

- 1 Harry hurt his thumb playing basketball in a PE lesson. His thumb shows the following symptoms:
 - 1 The skin around the thumb is red and warm.
 - 2 The thumb is in an abnormal position.
 - 3 There is swelling.
 - 4 He is not able to move his thumb.
 Which of the following symptoms suggests that this is more than just a bruise?
 - A Symptoms 1 and 2.
 - B Symptoms 1 and 4.
 - C Symptoms 2 and 3.
 - D Symptoms 2 and 4.

Figure 61 is an article about an injury that you can get from using a smartphone. Questions 2 to 4 are about the article.

▼ Fig. 61

Thumb injuries from smartphones

Children who often use a smartphone with their thumbs can get problems with their thumb joints. Small tears can appear in the tendons at the attachment sites of the muscles that move the thumbs. This causes pain that can radiate into the whole forearm, making it painful to move the hand.

The following symptoms can appear:

- a nagging pain in the ball of the thumb, the wrists and the lower arm;
- tingling in the fingers;
- a cold sensation in the hands and forearms;
- numbness in the hands and forearms.

What can you do about it?

If the pain is severe, you can cool the thumb down with iced water, for example. Once the worst of the pain has disappeared, you can start building up the workload again.

When you are getting going again, pain is a signal to take a break. Note: do not try to work through the pain barrier, because that will slow down the healing. You can wear a brace for a while as support. It is then also a good idea to switch between typing with the thumbs and typing with the fingers, and in particular not to use the smartphone for too long at a time.



- 2 What type of injury is involved here?
- A** Bruise.
B RSI.
C Muscle strain.
D Sprain.
- 3 There are advantages and disadvantages to cooling the injury. Which combination of advantage and disadvantage is correct?

	Advantage	Disadvantage
A	The thumb will heal more quickly at a lower temperature.	The blood circulation will be reduced, so the recovery will take longer.
B	The thumb will heal more quickly at a lower temperature.	The fluid in the thumb will become more viscous, so it will be able to move less easily.
C	The pain will be reduced.	The blood circulation will be reduced, so the recovery will take longer.
D	The pain will be reduced.	The fluid in the thumb will become more viscous, so it will be able to move less easily.

- 4 The text states that you must not push through the pain barrier. What does this mean?
- A** That you must be very careful when typing.
B That it is alright for you to feel a little pain while typing, but it must not hurt a lot.
C That you must stop typing as soon as you feel the pain.
D That you must not type for too long, because you will then get too tired.
- 5 Why is a plaster cast used for a broken bone?
- A** To keep the two halves of the bone in the right positions.
B To reduce the pain.
C To reduce internal bleeding.
D To prevent swelling.

- 6 The text in figure 62 is about an injury during a game of handball. You can use the information in the article to determine what kind of injury Anna probably has.

What kind of injury has she probably suffered?

- A A bruise.
- B A dislocation.
- C A muscle strain.
- D Tennis elbow.

▼ Fig. 62

Injured in a handball game

During a handball match, Anna suddenly felt a sharp pain in her triceps. It happened when she was shooting at goal. Her trainer treated the injury immediately with an ice pack. After an hour, Anna was still not able to put any strain on her arm, but there was nothing to be seen on the outside.



EXTRA OBJECTIVE 9

Answer the following questions.

Figure 63 is a drawing of the skull of a cat.

- 1 Which number indicates the temporal bone?
- 2 Which number indicates the cheekbone?

▼ Fig. 63

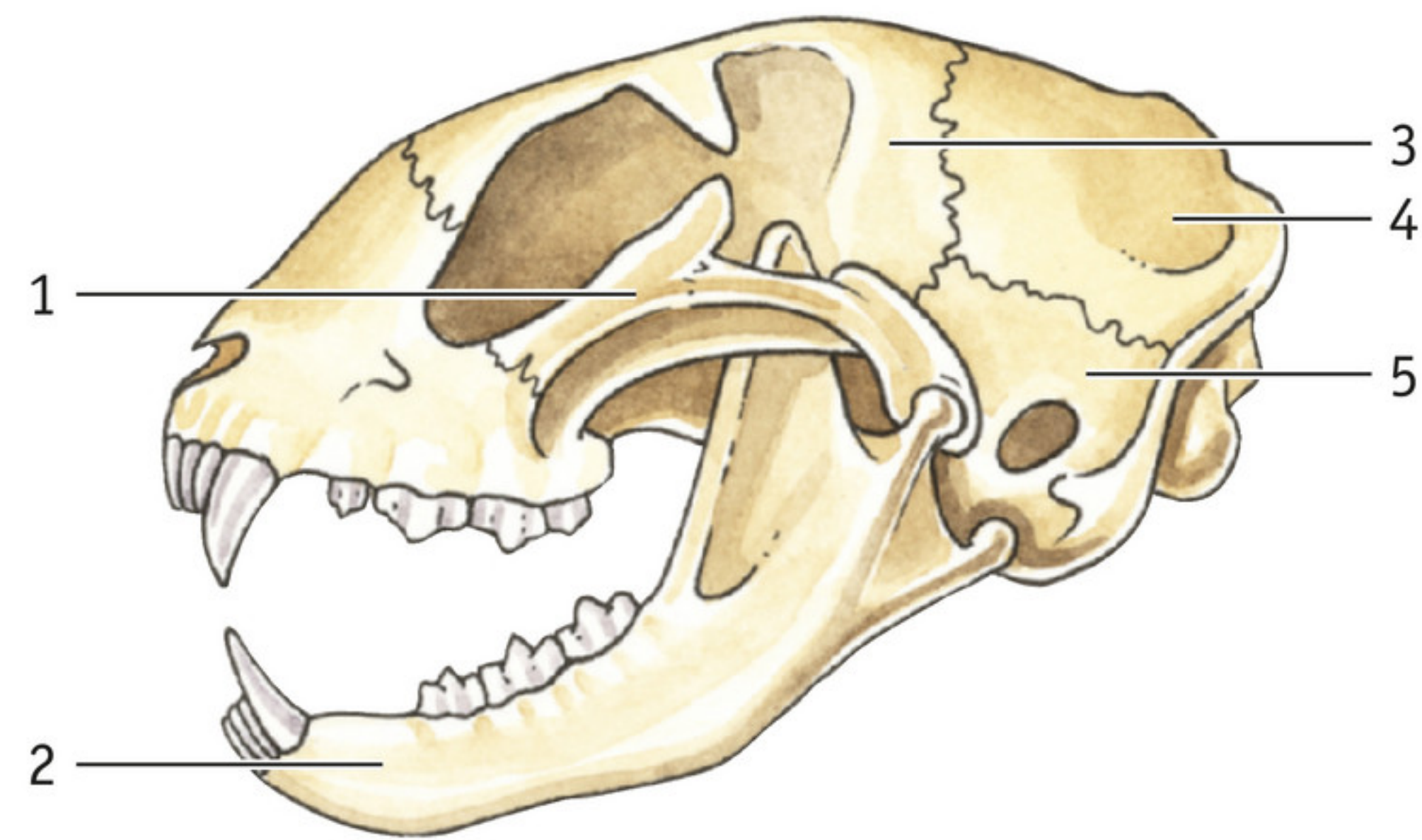


Figure 64 is a drawing of the skeleton of a frog.

- 3 What is the name of the bone labelled P?
- 4 The skeleton of the hind leg of a frog can be compared to the skeleton of a human leg. Name two bones in a human leg that are missing in a frog's leg.

▼ Fig. 64

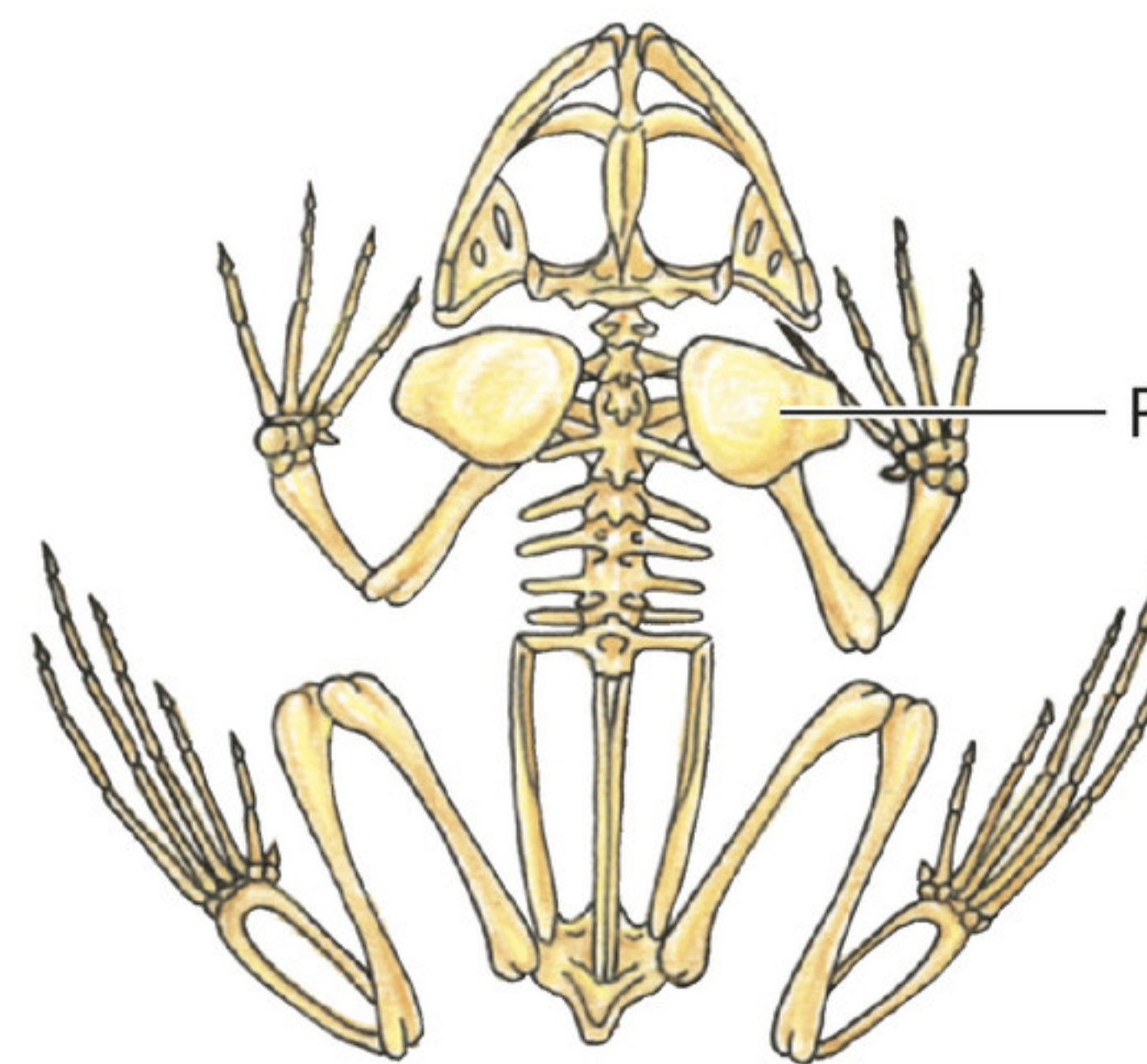


Figure 65 shows the front leg of a mole.

- 5 What is the name of the bone labelled Q?
- 6 What is the name of the bone labelled R?

▼ Fig. 65

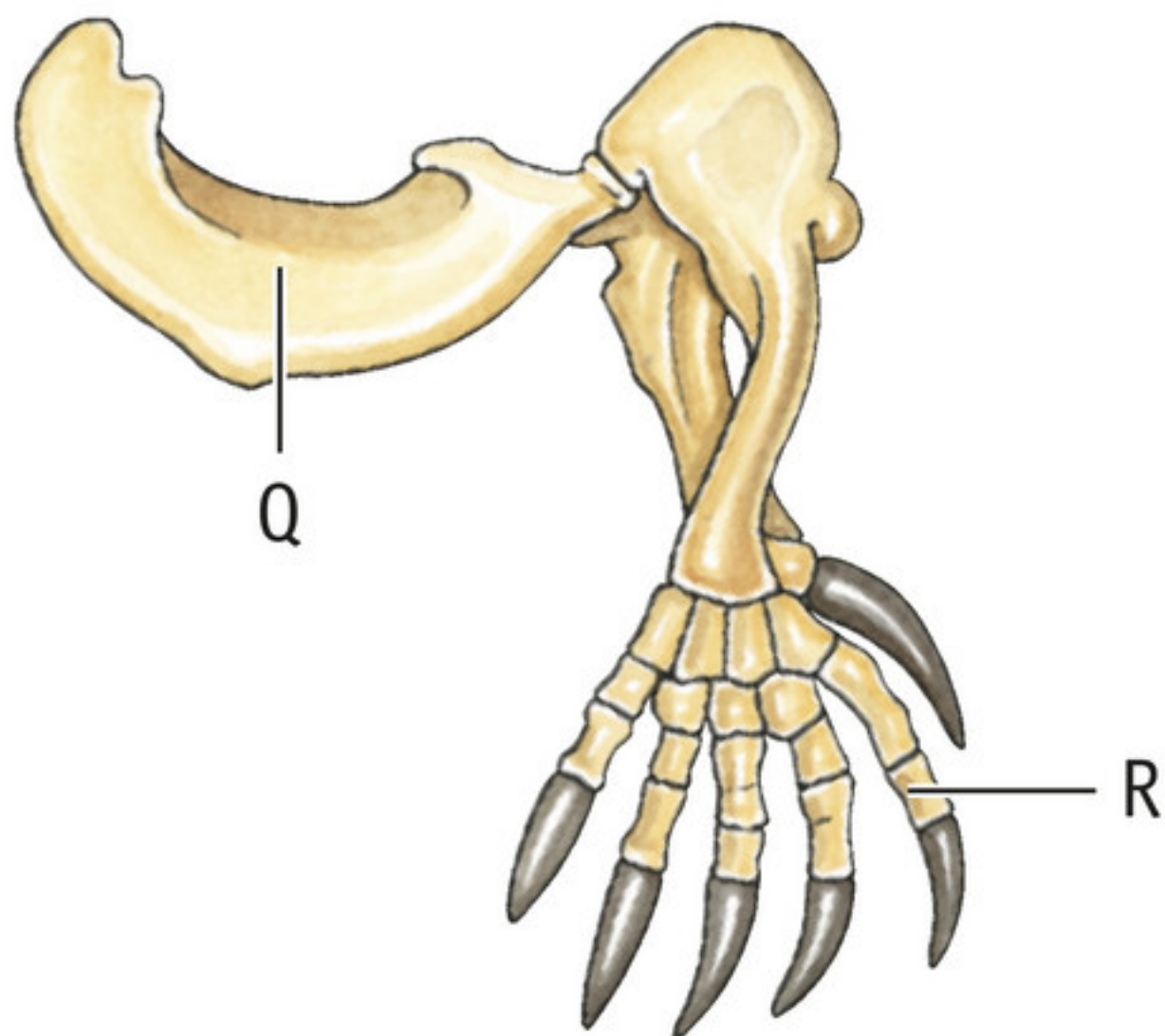
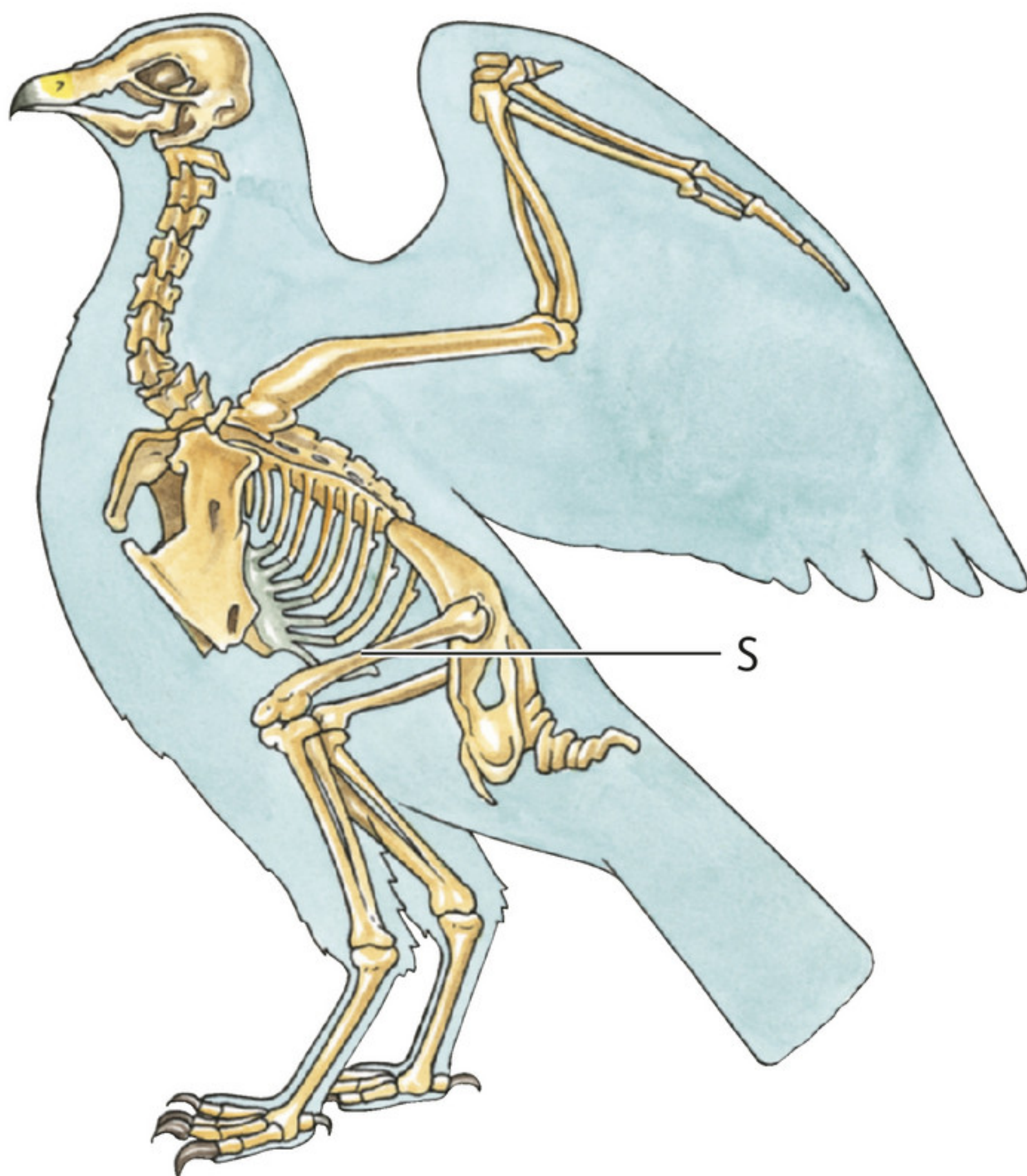


Figure 66 is a drawing of the skeleton of a hawk.

- 7 What is the name of the bone labelled S?

▼ Fig. 66



EXTRA OBJECTIVE 10

The scoresheet has a table with columns for two back problems: a slipped disc and lumbago.

Answer the following questions by placing crosses in the correct column (or columns).

- 1 In which condition does the back pain radiate out to a leg?
- 2 Which condition is caused by something breaking?
- 3 Which condition occurs suddenly?
- 4 Which condition is caused by muscle spasms?
- 5 Which condition is caused by the intervertebral discs?

You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three topics. You can do the exercises for them in your workbook.

1 The shape of feet

Many structures we build are arched. Figure 67 shows an arched railway bridge, for example. The same shape also appears in the human foot (see figure 68). The sole of your foot is **arched**. In this extension, you are going to investigate why this is useful. You will have to carry out an experiment, make footprints (see figure 69) and answer questions.

WB EXERCISES 1 TO 3, PAGE 35

► Fig. 67 A railway bridge.



▼ Fig. 68 A foot has an arch.



▼ Fig. 69 A footprint.

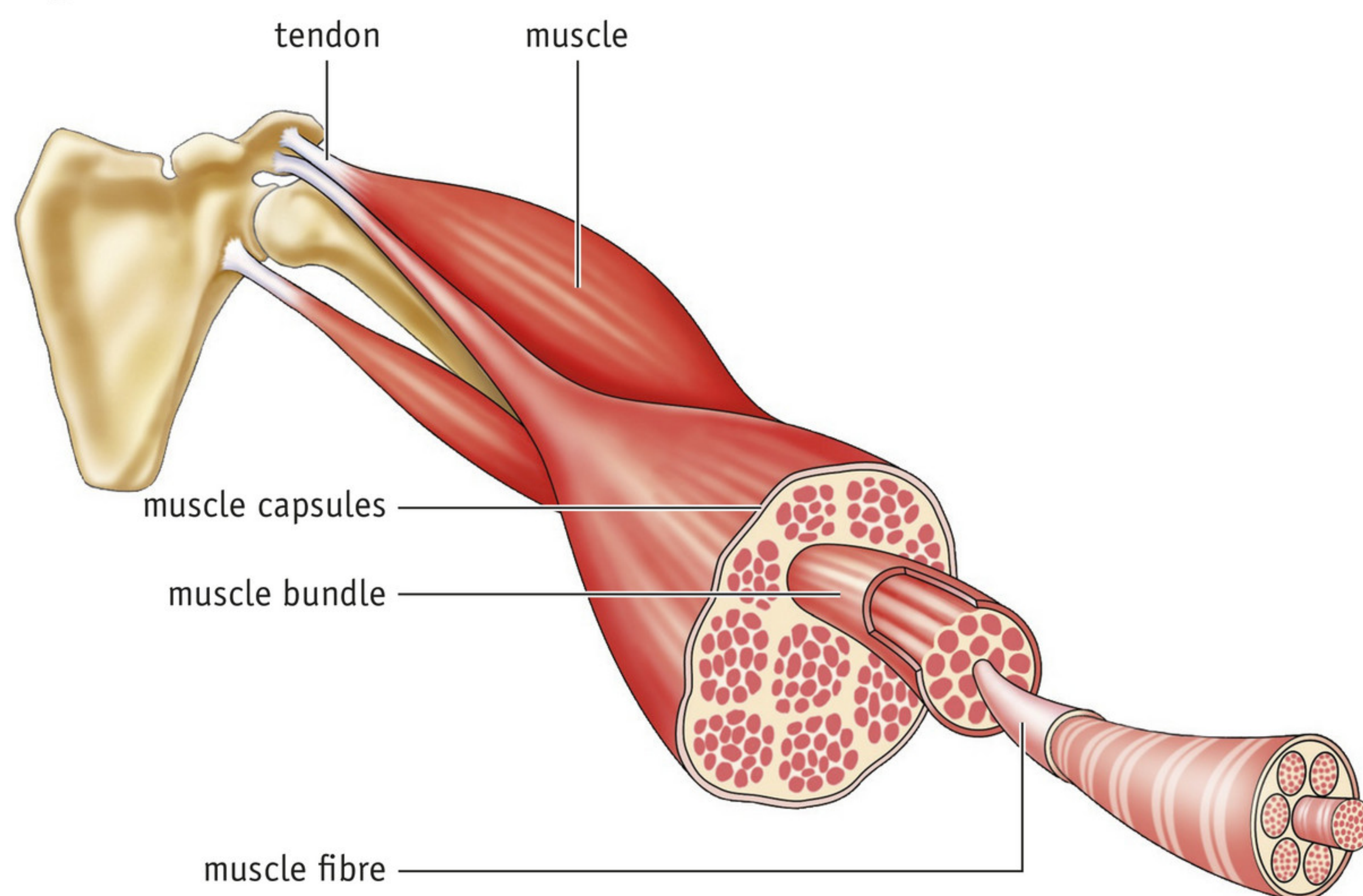


2 Muscle tissue

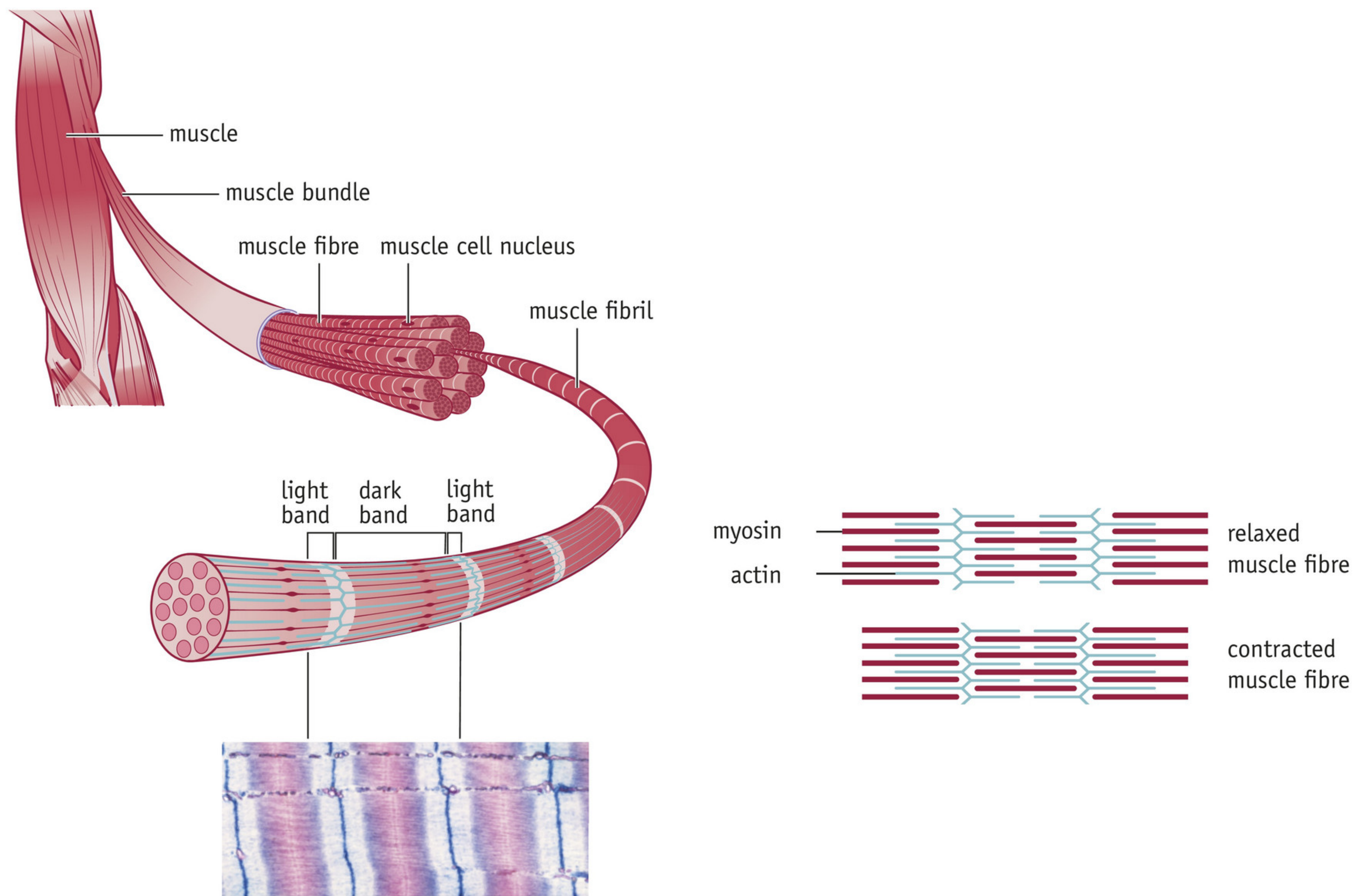
In the basics, you learned that muscles generate movements by contracting. In this extension, you will learn about the structure of a muscle and about the different kinds of muscle tissue. You will have to answer questions and you will examine muscle tissue under a microscope.

A muscle is surrounded by connective tissue called the **muscle sheath**, which extends at both ends of the muscle to become a **tendon** (see figure 70). A skeletal muscle consists of a number of **muscle bundles** that are each surrounded in turn by a layer of connective tissue. Each muscle bundle consists of a number of **muscle fibres**. Muscle fibres are made up of muscle fibrils, which are made of the proteins actin and myosin. When a muscle contracts, actin and myosin molecules slide along to overlap one another, making the muscle shorter and thicker. At points where the molecules overlap, the colour is a little darker than where they do not. If you examine skeletal muscle tissue under a microscope, you can then see lots of stripes (striations) in the muscle tissue (see figure 71). This type of muscle tissue is called **striated muscle tissue**.

▼ **Fig. 70** The structure of a muscle.



▼ Fig. 71 Striated muscle tissue.



In the involuntary muscles – the ones you cannot control, such as the muscles in your intestines – the muscle fibrils are not so neatly aligned. You cannot therefore see striations on these. This type of muscle tissue is known as **smooth muscle tissue**.

The contractions of striated muscle tissue are rapid and powerful. The contractions of smooth muscle tissue are slower. As a result, smooth muscle tissue does not tire as quickly as striated muscle tissue.

WB EXERCISES 1 AND 2, PAGE 37

3 Powerhouses

Everyone has muscles. We use our muscles to make our bones move. This lets us walk or lift a suitcase, for example. But we can't all break the world sprint record, and we are not all equally strong either. So our muscular systems do differ.

We are not all equally tall or heavy either. Height and weight affect how quick and how strong we are. Tall people can for example take longer strides than short people. Someone who trains a lot gets thicker and stronger muscles because more muscle tissue is produced.

To decide who is the strongest, many sports divide people up into different weight categories. To see which animals are strongest, scientists also use an objective way of comparing them. They calculate how many times its own bodyweight an animal can lift. Those calculations show that the strongest animal in the world is a blind moss mite. This mite weighs 0.1 mg and can lift up to twelve hundred times its own weight. The dung beetle is also very strong. This beetle can lift balls of dung that are a thousand times heavier than it is. Finally, ants are also very strong: they are able to lift fifty times their own bodyweight.

WB EXERCISES 1 AND 2, PAGE 39

► **Fig. 72** Powerhouses.



1 human



2 dung beetle

6

Senses, coordination and behaviour



BASICS

- 1 Responding to your surroundings
- 2 The skin
- 3 The nose and tongue
- 4 The ears
- 5 The eyes
- 6 The nervous system
- 7 Behaviour
- 8 The endocrine system

52
56
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60
65
69
72
78

EXTRA

- 9 The brain 82
- 10 Paths taken by nerve impulses 85

SUMMARY AND DIAGNOSTIC TEST

- Summary 88
- Diagnostic test 92

EXTENSION

- 1 Optical illusions 100
- 2 Seeing depth 102
- 3 Spiral puzzle 103



This unit is called 'Senses, coordination and behaviour'. You can sense things around you: you can see, hear, smell, taste or feel them. You use your sense organs to sense things. Your senses let you keep track of your environment. They let you respond to what is going on around you.

You may respond in many ways, for instance by talking, laughing or moving. Together, all your responses are your behaviour.

A great deal has to be done to make sure that the processes in your body run smoothly. The nervous system and the endocrine system play key roles in this.

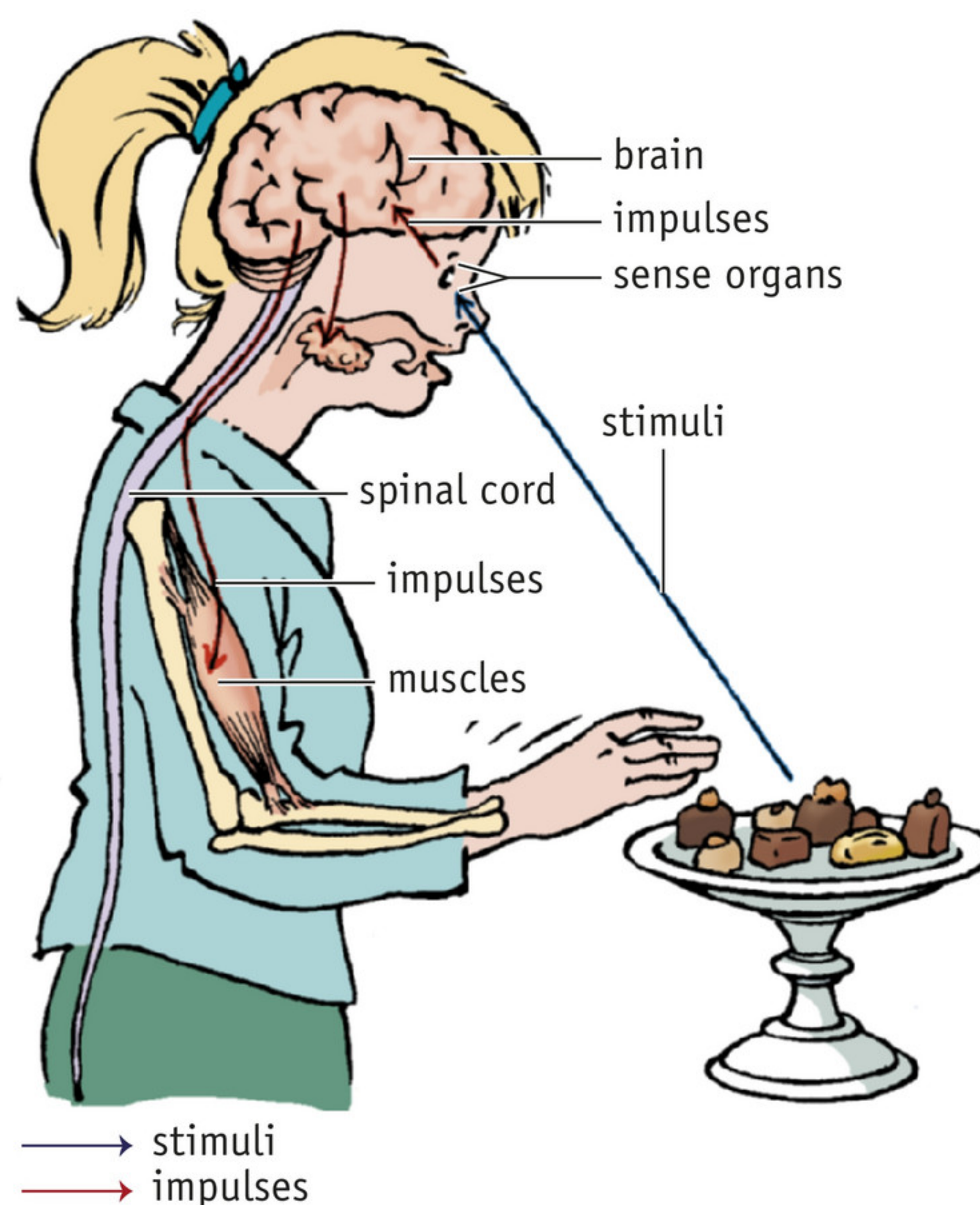
When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 Responding to your surroundings

You see and smell chocolates on a plate. You would like to eat one and your mouth starts watering. You take a piece of chocolate and start eating it. Figure 1 shows what happens in your body.

When you see and smell the chocolate, you are using the **sense organs** in your eyes and in your nose. These sense organs send out signals called impulses that go through your **nerves** to your **brain**. Your brain processes these signals and responds by sending out other signals. These signals go through your nerves to your **arm muscles**. Your arm muscles then contract: you can pick up the piece of chocolate and put it in your mouth.

► **Fig. 1** The sight and smell of food makes your mouth water.



SENSE ORGANS

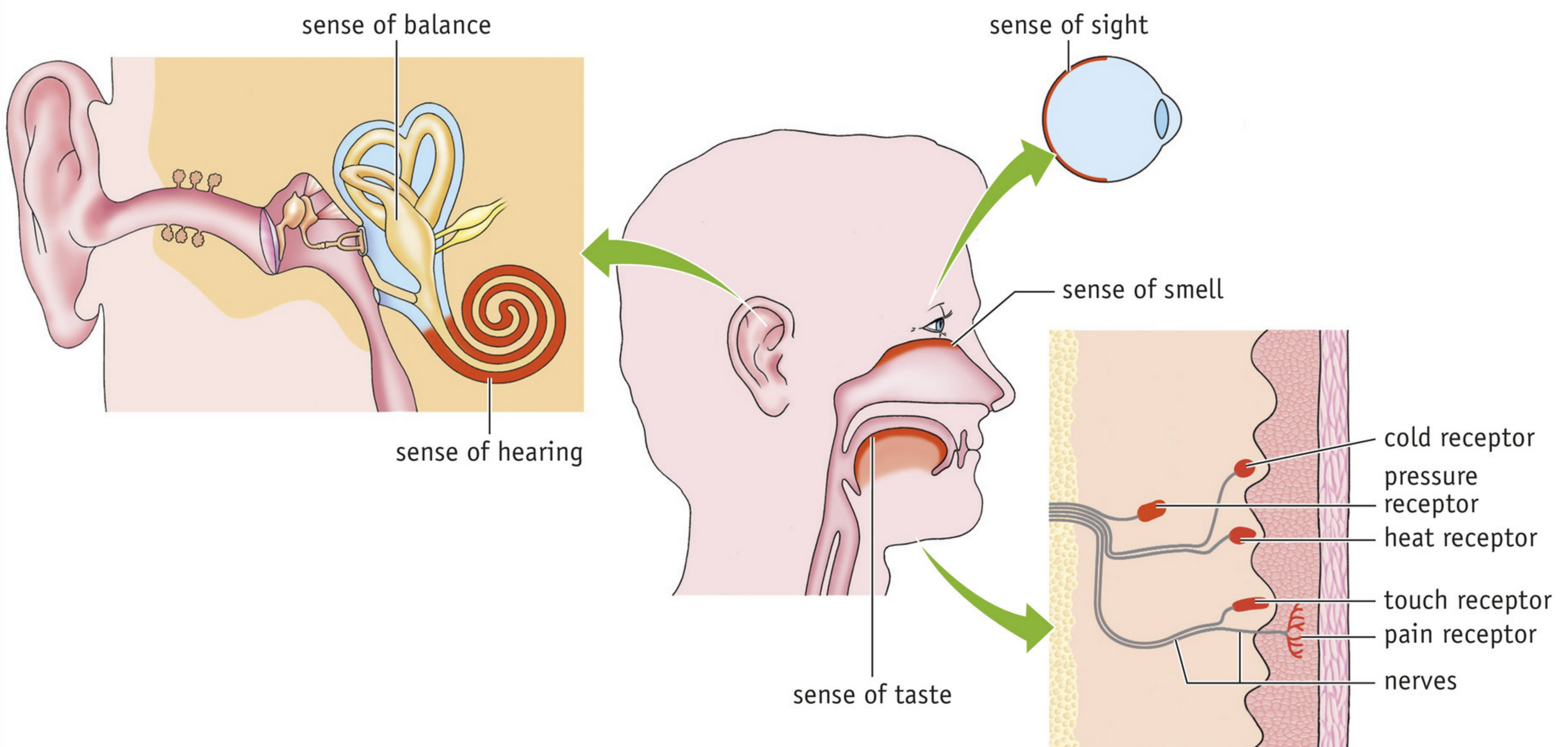
Your body contains a lot of sense organs. The most familiar sense organs are in your eyes and ears. But there are also sense organs in your nose, your tongue and your skin. Together, all your senses form the **sensory system**.

Figure 2 shows the locations of some of these senses. You can see that your ears contain two sense organs: the **sense of hearing** and the **sense of balance**.

Your skin has sense receptors that give you your sense of touch. However, you can feel things in various ways. Your skin therefore also has various types of sense receptors: heat receptors, cold receptors, pressure receptors and touch receptors.

Heat receptors respond when something that is warmer than your skin touches it. The **cold receptors** respond when your skin touches something that is colder than your skin. **Pressure receptors** respond to pressure on your skin. Pressure receptors are found deeper in your skin. **Touch receptors** respond to light contact with your skin. Your touch receptors let you sense how objects feel, for instance whether they are smooth, rough, hard or soft. The different types of receptors in the skin are shown in figure 2.

▼ **Fig. 2** Location of some of your sense organs. Sensory cells can be found in the areas coloured red.



A sense organ is an organ that reacts to certain information from the surroundings. Such information from the surroundings that has an effect on an organism is called a **stimulus**. Examples of stimuli are (rays of) light, sounds, smells and skin contact. Because our sense organs are sensitive to stimuli, we can sense all kinds of things.

The sense organs have **sensory cells**. Sensory cells are connected to **nerves**. When sensory cells receive stimuli, they generate **impulses**. Impulses are a kind of electrical signal. Impulses are transmitted to the brain by nerves.

▼ Fig. 3 A non-adequate stimulus.



HOW IMPULSES START

Impulses are only produced in sensory cells if a stimulus is strong enough. The lowest intensity of the stimulus that can cause an impulse is called the **threshold value**. If a stimulus is weaker than the threshold value, impulses will not be produced in the sensory cells. You will not hear a very soft sound, for instance.

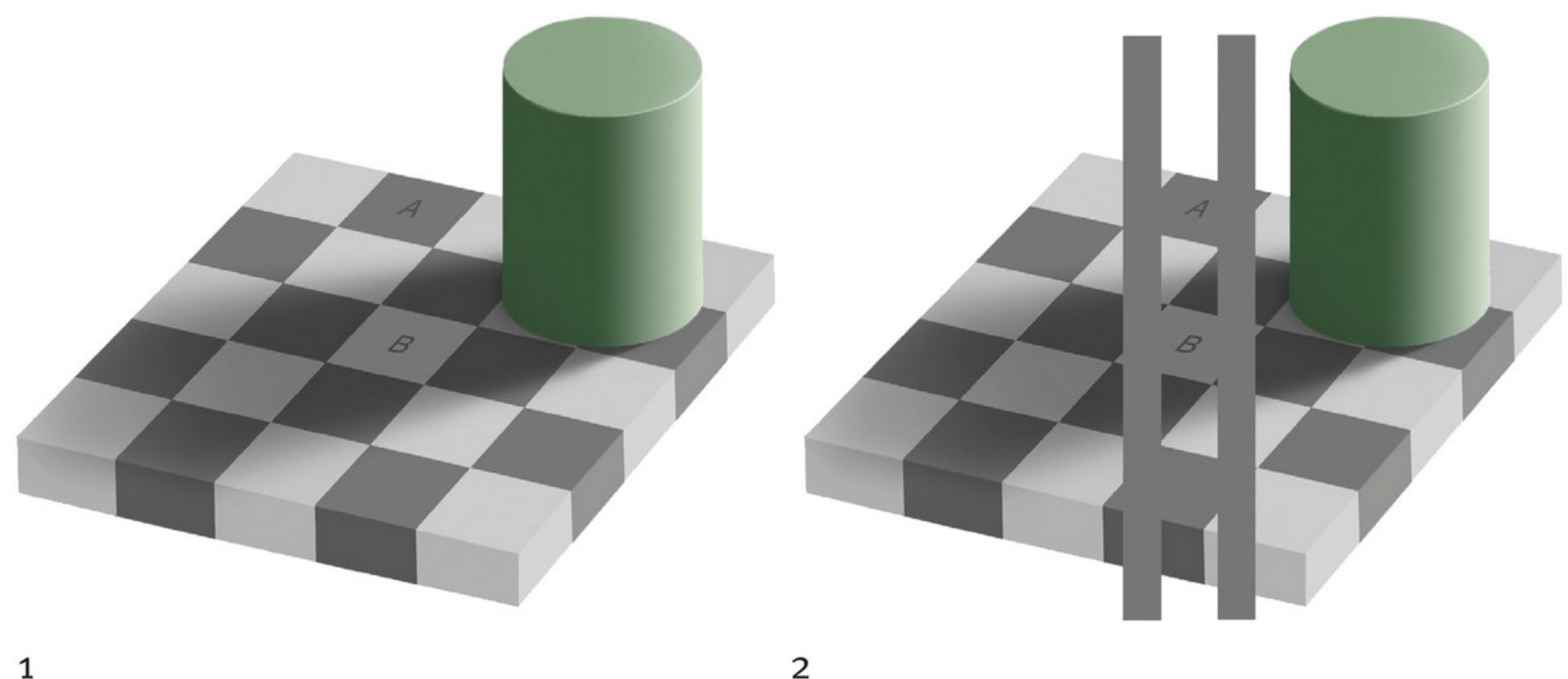
Each type of sensory cell has a specific threshold value for each type of stimulus. The threshold value of sensory cells in your eyes is very low for light stimuli. As a result, the sensory cells in your eyes are particularly sensitive to light. We therefore call light the **adequate stimulus** for the sensory cells in your eyes. An adequate stimulus is the type of stimulus that a sensory cell is particularly sensitive to. The sensory cell has a low threshold value for this stimulus.

Each type of sensory cell has its own specific adequate stimulus. However, sensory cells can also perceive other, non-adequate stimuli (see figure 3). The threshold value for these non-adequate stimuli is much higher, though. If you close your eyes and press your eyelids gently with your fingers, for instance, you will see nothing. The stimulus is lower than the threshold value. But if you get hit hard on your eyes, you will 'see stars'. The blow produces impulses in the eyes, which are passed to the brain and are interpreted as seeing stars.

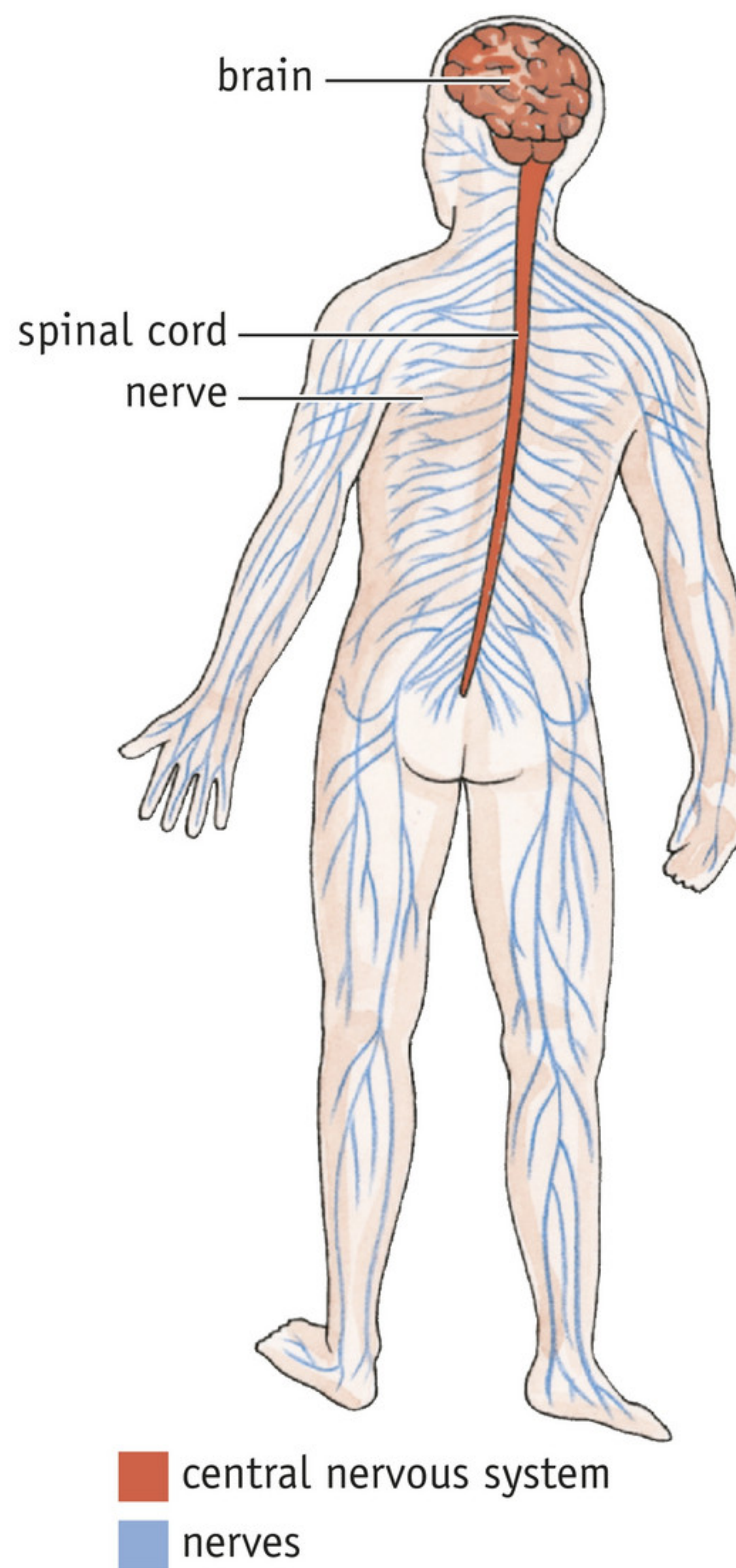
The threshold value for a stimulus is not always the same. If a stimulus does not go away for some while, it starts producing fewer impulses in the sensory cells. This is called **habituation**. Because of habituation, you do not feel the pressure of your clothing on your body after a little while, for instance.

Motivation plays a role too. When you are listening very carefully, the sensory cells in your ears have a lower threshold value for sounds. Finally, the brain can affect your perceptions too. In figure 4.1, for instance, it looks as if square A is darker than square B. Drawing two bars through squares A and B, as has been done in 4.2, lets you see that in reality both squares are equally dark. When processing the impulses, the brain creates the difference between dark and light.

► Fig. 4 Perceptions are affected by the brain.



▼ **Fig. 5** The nervous system (schematic).



THE NERVOUS SYSTEM

Sensory cells transmit impulses to nerves. In part 1a, you learned that all nerves are part of the nervous system.

Figure 5 shows a diagram of the human nervous system. The nervous system is made up of the **central nervous system** and the **nerves**. The central nervous system consists of the **brain** and the **spinal cord**. The nerves connect the central nervous system to all parts of the body.

Figure 1 has shown you an example of how the nervous system works. In figure 1, the impulses produced in the sensory cells of your eyes are transmitted to your brain by nerves. The impulses that are produced in sensory cells in your nose are passed to the brain by a different nerve.

Your brain processes the impulses that come from all your sense organs. You then become aware of the things that you are perceiving. Then you can respond consciously to the stimuli that your senses have received. If you respond consciously, impulses are produced in your brain. In figure 1, nerves transmit those impulses to your salivary glands and to the muscles in your arm. Your salivary glands respond to the impulses by producing saliva. This makes your mouth water. Certain arm muscles respond to the impulses by contracting. This lets you pick up a piece of chocolate and put it in your mouth.

Senses respond to stimuli by sending out impulses. The nervous system processes the impulses that come from the sense organs. The nervous system also controls the working of muscles and glands.

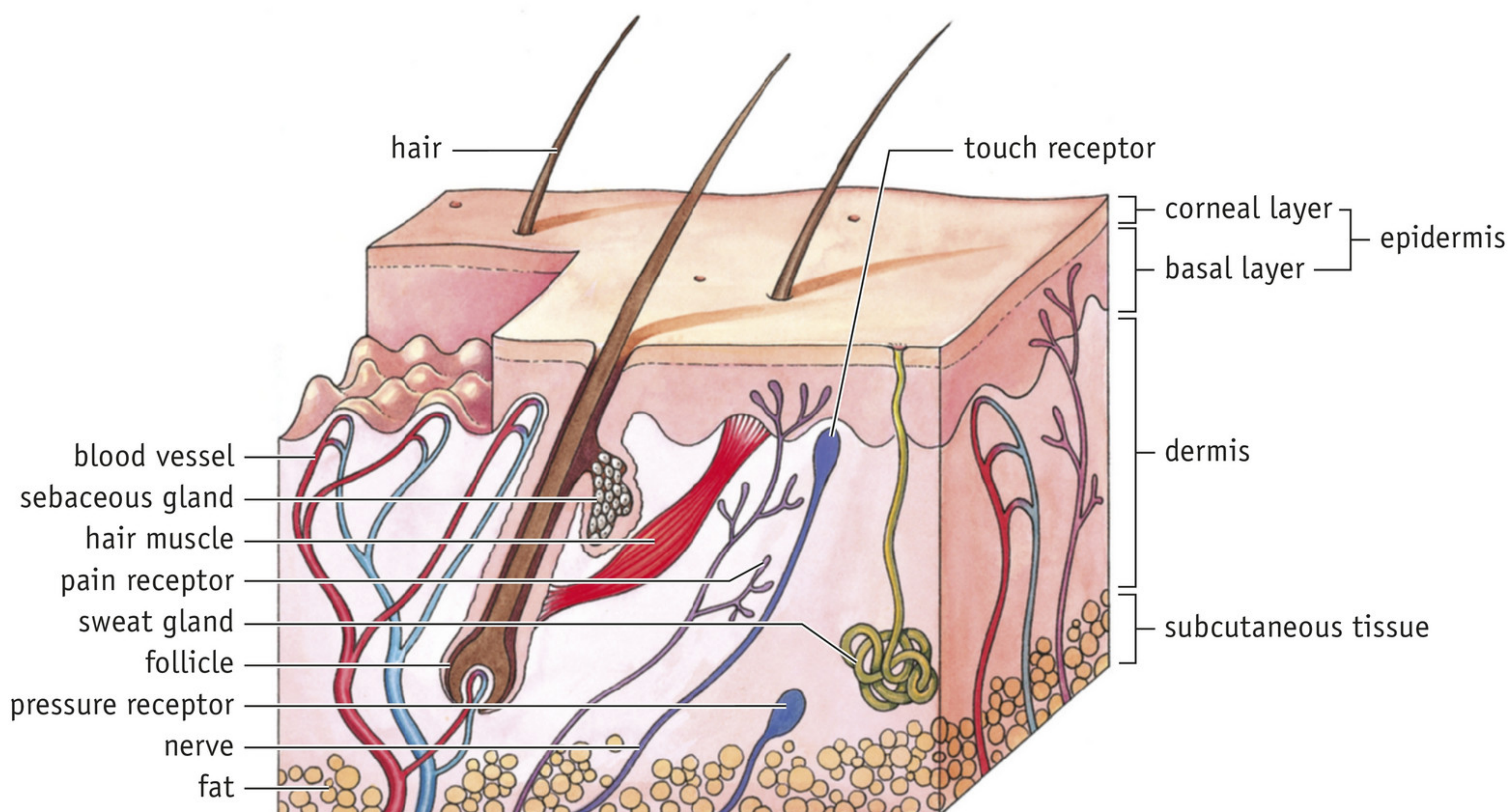
As well as the impulses that the senses receive, you can also perceive **pain**. **Pain receptors** let you perceive pain. These are the endings of certain nerves. You can see pain receptors in the skin in figure 2. Pain receptors can be found at many places in your body, even in deeper-lying organs.

WB EXERCISES 1 TO 6, PAGE 42

2 The skin

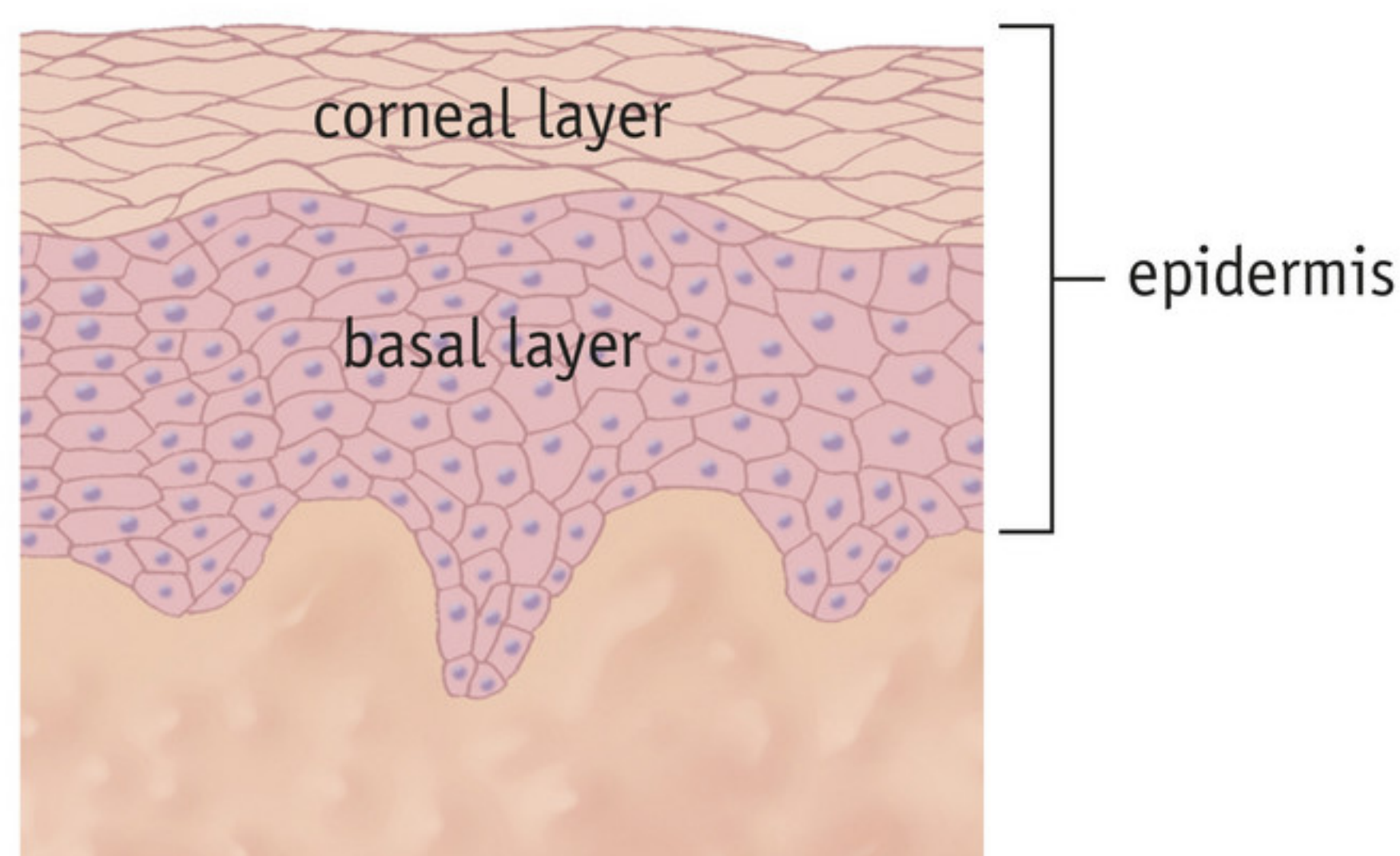
You have learned that the skin contains a number of receptors that tell you how things feel. Figure 6 is an illustration of a cross section through the skin. The skin is made up of two parts: the epidermis and the dermis.

▼ **Fig. 6** The skin and subcutaneous tissue.



The **epidermis** has two layers: the corneal layer and the basal layer. The **corneal layer** consists of the remains of dead, cornified cells. The corneal layer protects your body against damage, dehydration and pathogens (bacteria). The **basal layer** consists of living cells (see figure 7). The cells at the bottom of the basal layer are continuously dividing. This keeps creating more new basal layer cells. The basal layer cells on top move upwards until they are on the outside. These cells become cornified. This means that they produce a lot of keratin. Keratin can be found in nails and in hair too. Once a cell has become cornified, it dies off.

► **Fig. 7** Cornification of the epidermis.



The corneal layer is continually wearing off on the outside. This layer is thicker in some places (the soles of your feet, for example). These toughened areas are called **calluses** (see figure 8).

Hairs stick out through the epidermis. In the skin, a hair is surrounded by a **follicle**. A follicle is a part of the basal layer that protrudes into the dermis. A hair grows from the bottom of the follicle. The follicles contain **sebaceous glands** that produce **sebum**, a fatty substance that keeps the hair and the corneal layer flexible.

► **Fig. 8** A file used for filing off excess callused skin.



The **dermis** has the heat receptors, cold receptors, pressure receptors and touch receptors. The sense of touch comes from touch receptors that are just beneath the basal layer (see figure 6). The pressure receptors are found deeper in the skin. The heat receptors, cold receptors, pressure receptors and touch receptors work together to give you your overall sense of touch. The dermis also contains **nerves** with **pain receptors**, as well as **hair muscles**, **blood vessels** and **sweat glands** (see figure 6). The sweat glands produce sweat, particularly when you are hot. Evaporation of sweat lets your body cool down. New sweat glands are produced during puberty.

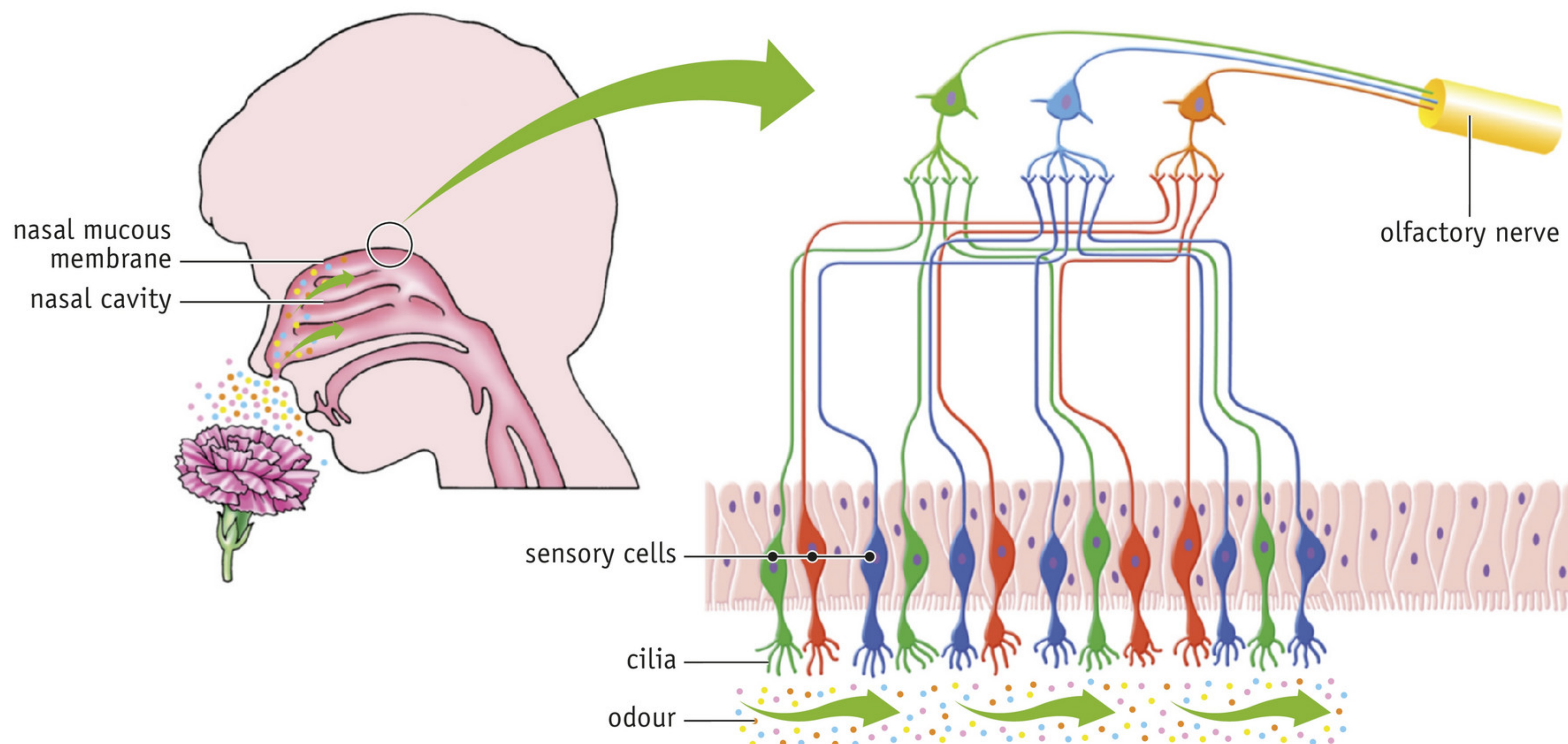
The **subcutaneous tissue** lies beneath the skin. The fat stored in this tissue serves as an energy reserve. This fat also forms an insulating layer that prevents loss of heat of the body.

WB EXERCISES 7 TO 10, PAGE 47

3 The nose and tongue

The **sense of smell** is found in the nose. The nasal cavity is lined with a **mucous membrane**. The upper part of the nasal mucous membrane contains sensory cells with hairs called **cilia**. These sensory cells are stimulated when various molecules go past them. The sensory cells then generate impulses that are transmitted to the brain by the nerves.

▼ Fig. 9

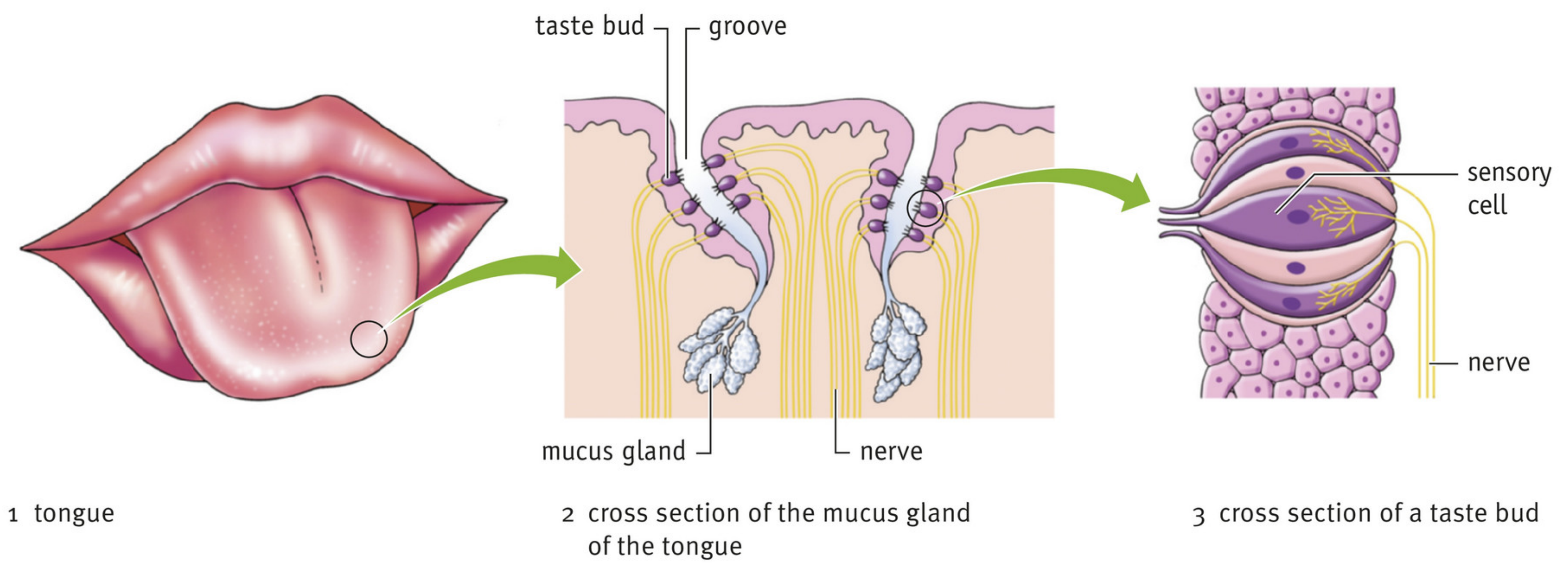


Most odours consist of all kinds of different substances. When you breathe in the scent of a flower, those substances flow past the cilia of the sensory cells (see figure 9). The nasal mucous membrane contains a lot of different sensory cells. Each type of sensory cell is sensitive to a particular substance. All the sensory cells together send out a certain pattern of impulses to the olfactory nerve for each different smell. Your brain translates these impulses and you smell the flower.

The **taste receptors** are on the surface of the tongue. The surface of the tongue has a lot of very small grooves. The sides of these grooves have **taste buds** (see figure 10). The taste buds contain the sensory cells for taste. The sensory cells for taste in your tongue can only distinguish between four types of taste: sweet, salty, sour and bitter. There are separate taste buds for each of these four tastes. The sense of smell in your nose plays an important role in all the other flavours that you perceive.

WB EXERCISES 11 AND 12, PAGE 51

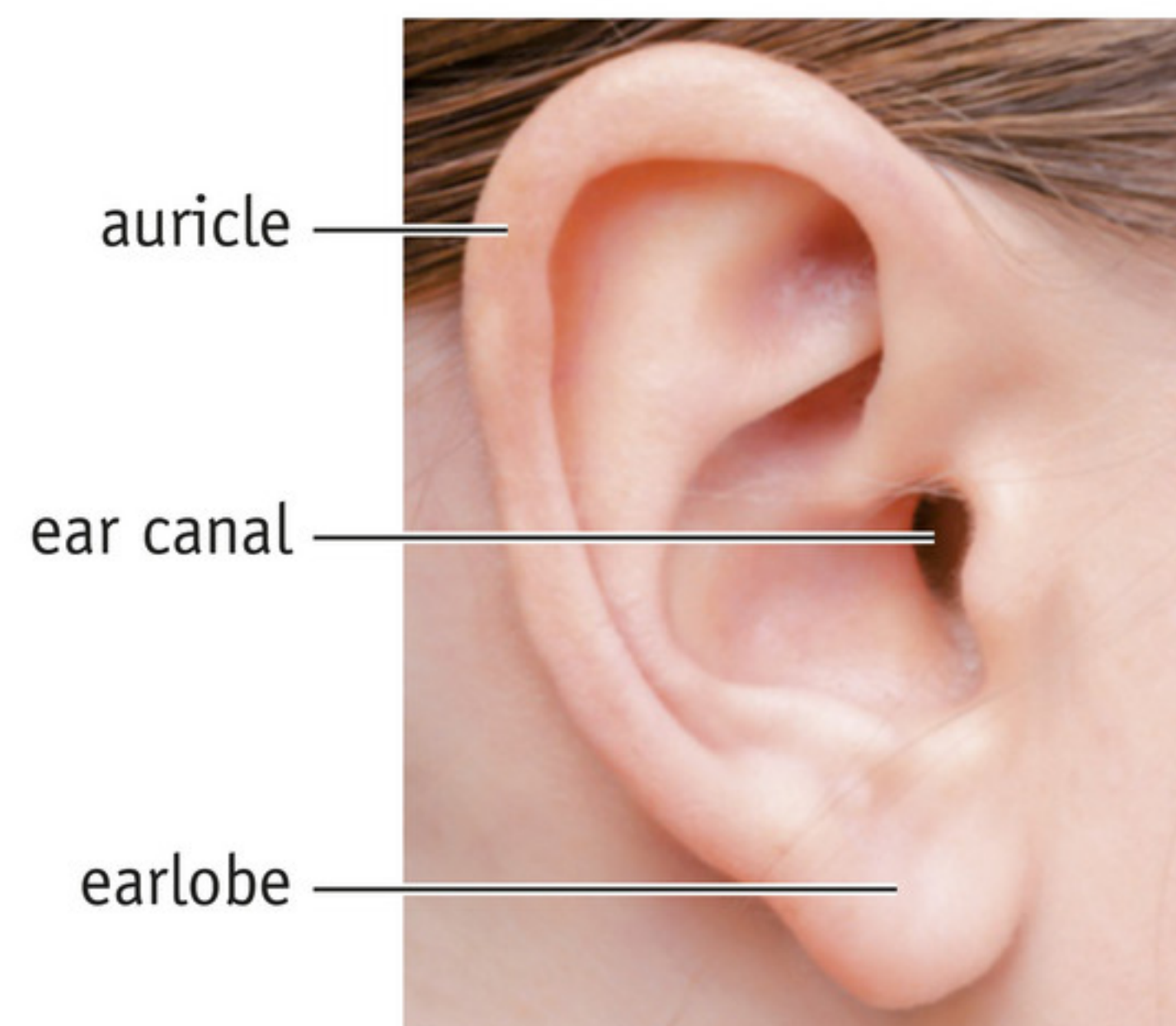
▼ **Fig. 10** Taste receptors.



4 The ears

In Basics 1, you learned that the sense of hearing and the sense of balance are found in the ears. When you talk about ears, you usually only mean the outer ear or auricle (see figure 11). However, the hearing organs are largely inside your skull.

► **Fig. 11** Outer ear.

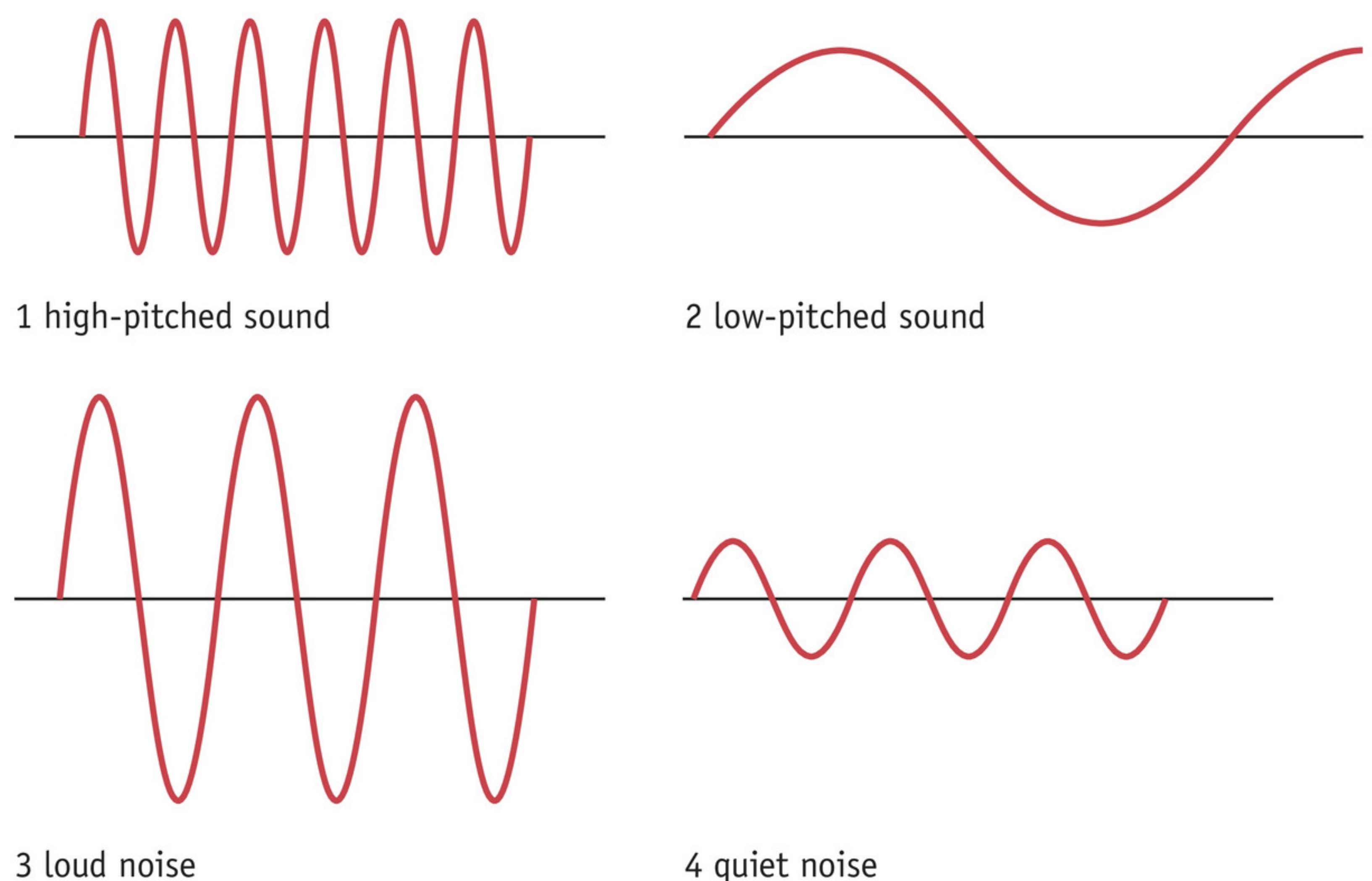


SOUNDS

Your **sense of hearing** lets you perceive sounds. Sounds are vibrations in the air. When the air vibrates quickly, the sounds are high pitched. Sounds are low pitched when the air vibrates slowly. If the vibrations move the air a lot, the sound will be loud. And if the vibrations do not move the air much, the sound will be quiet (see figure 12).

For a sound that becomes higher in pitch, there will be a certain moment that you will not be able to hear it. What pitches you are only just able to hear also depends on your age. As you grow older, you will be increasingly less able to hear high-pitched tones.

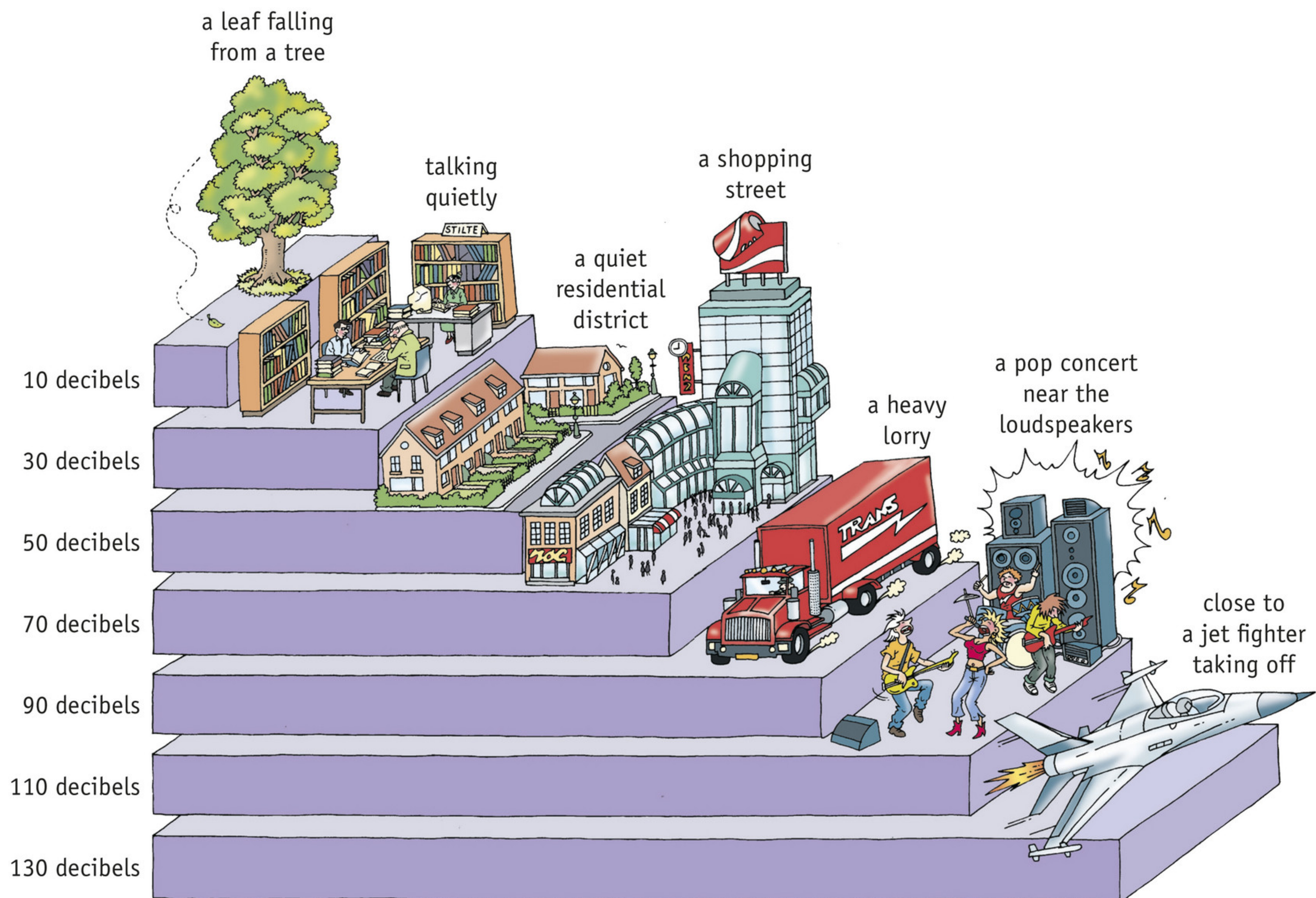
► **Fig. 12** Sounds are vibrations in the air.



The **volume** (the loudness) of a sound is expressed in **decibels**. Figure 13 shows a scale of noise levels. Sounds from 80 decibels (dB) upwards can cause hearing damage if you listen to these sounds too often and for too long. You will then have more and more trouble hearing (see figure 14). In the long run you may even go deaf. Sounds from 130 decibels upwards cause severe earache.

WB EXERCISE 13, PAGE 53

▼ **Fig. 13** A scale of noise levels in decibels.



▼ Fig. 14

Hearing damage caused by music from earphones

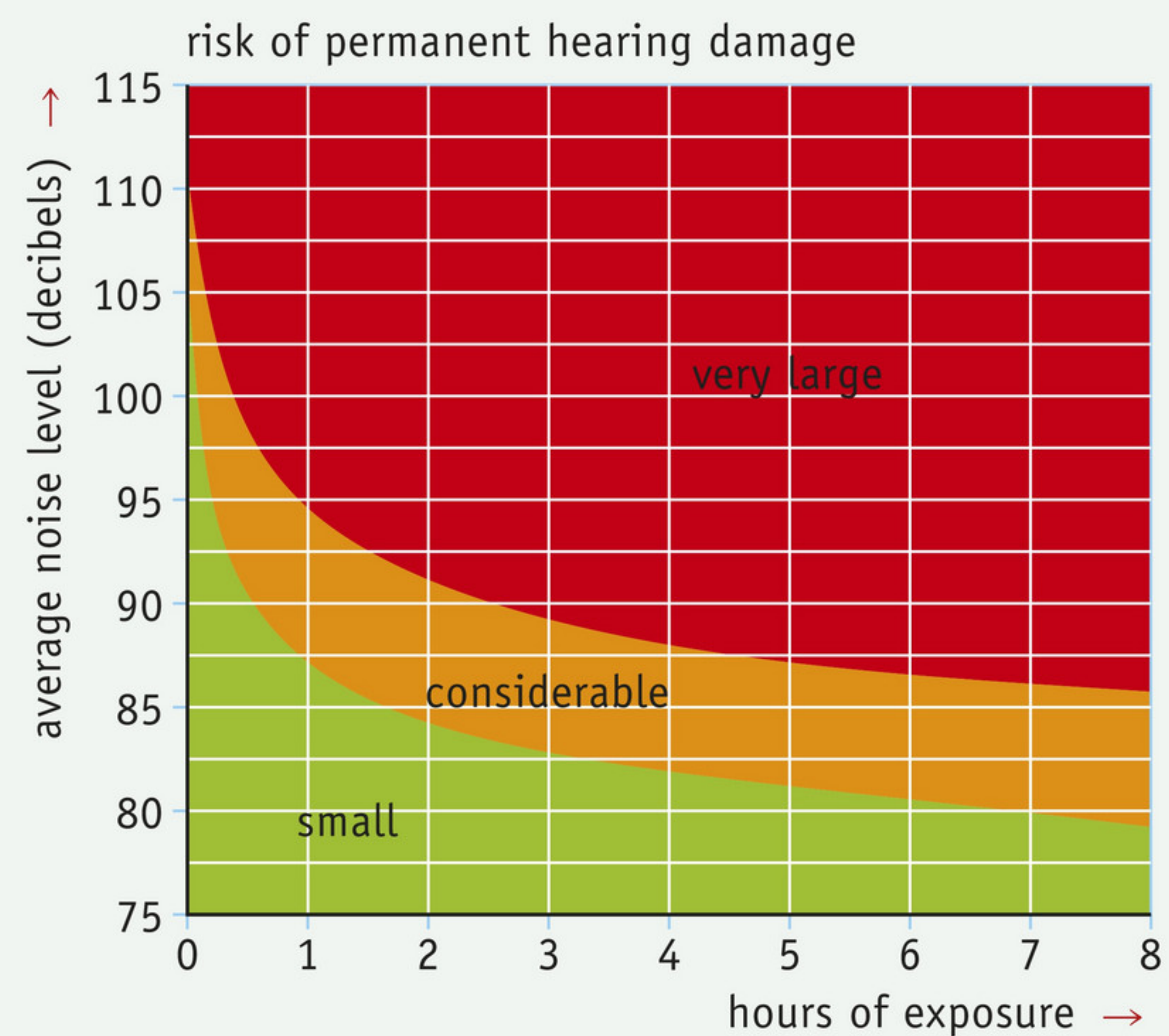
AMSTERDAM – Almost three quarters of young people are aware that they run a risk of getting hearing damage if they are exposed to noise for too long in clubs or discos. Earphones in music players are frequently used, though, and they can be a big risk too. There was loud music and noise in the past too, but today's young people run a greater risk of hearing damage. They listen to music more often and for longer using earphones or headphones, with the volume frequently set to the maximum.

Music players such as iPods and other MP3 players are lighter and smaller than ever and young people often have one with them. These music players contain enormous amounts of music and the batteries are lasting longer and longer too. The duration of the exposure to noises above 80 decibels has therefore

increased enormously. Since 2013, music players have been required to have volume limiters, and you will see a message when you set the volume to more than 85 decibels.

The problem is that while young people are aware that loud music is not good, they do not notice the consequences immediately. Hearing damage is cumulative, building up slowly. A lot of young people therefore never take precautions to prevent or reduce hearing damage, although they are aware of these dangers.

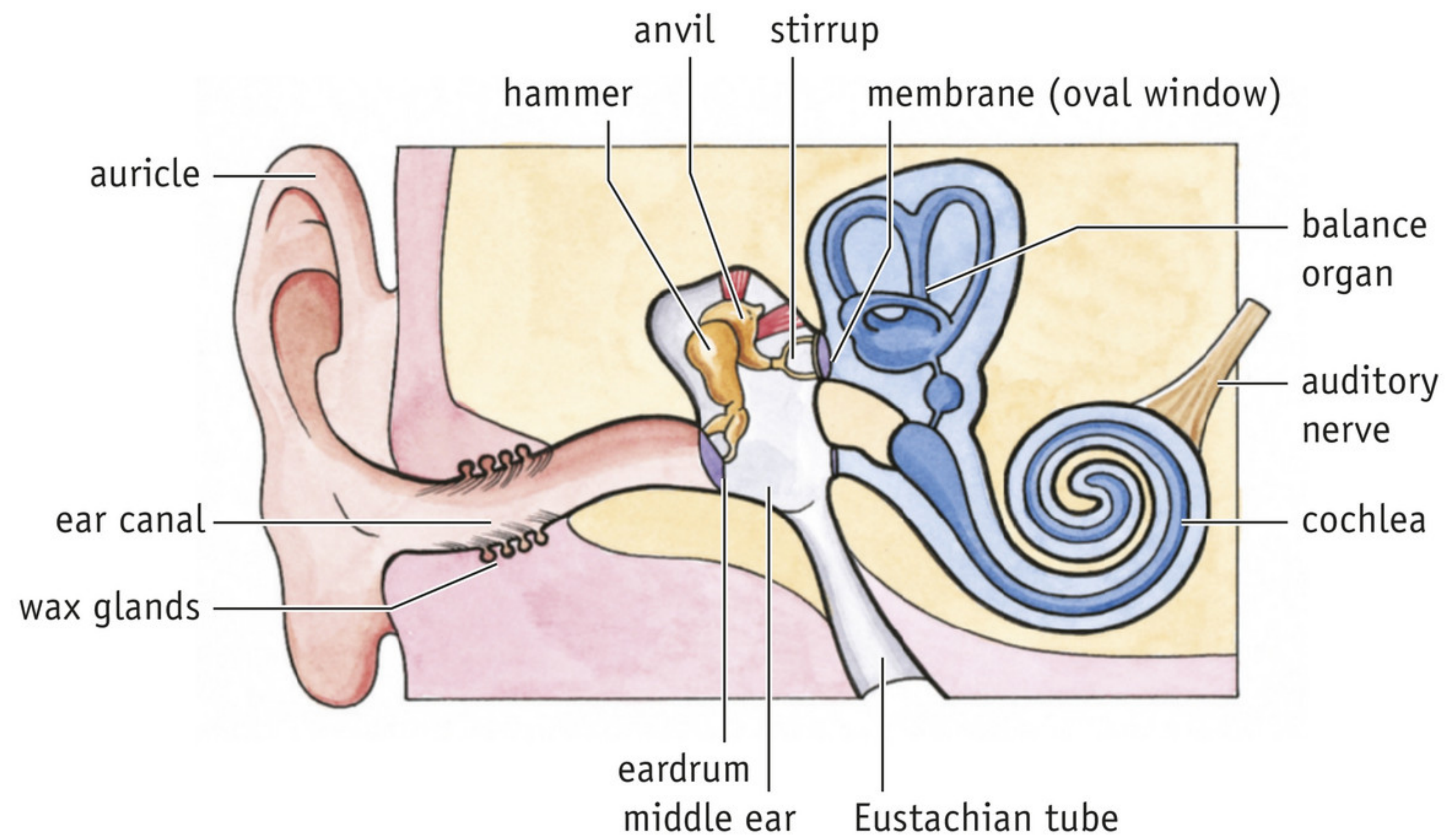
It turns out that hearing aids are not popular. When interviewed, no less than 85% of young people say that wearing a hearing aid would be a problem or even a big problem.



THE STRUCTURE OF THE EAR

Figure 15 shows a schematic drawing of the structure of an ear. An ear contains the sense organs for **hearing** and balance. The function of the **auricle** is to collect sounds. The sounds reach the **eardrum** via the **ear canal**. They can make the eardrum vibrate. The ear canal has small **wax glands** that produce earwax. The earwax keeps the eardrum flexible to make sure it vibrates properly.

► **Fig. 15** An ear.



Behind the eardrum is the **middle ear**. It contains three tiny bones called **ossicles**: the **hammer**, the **anvil** and the **stirrup** (see figure 16). The stirrup is connected to a **membrane** in the **cochlea**. This membrane is known as the **oval window**.

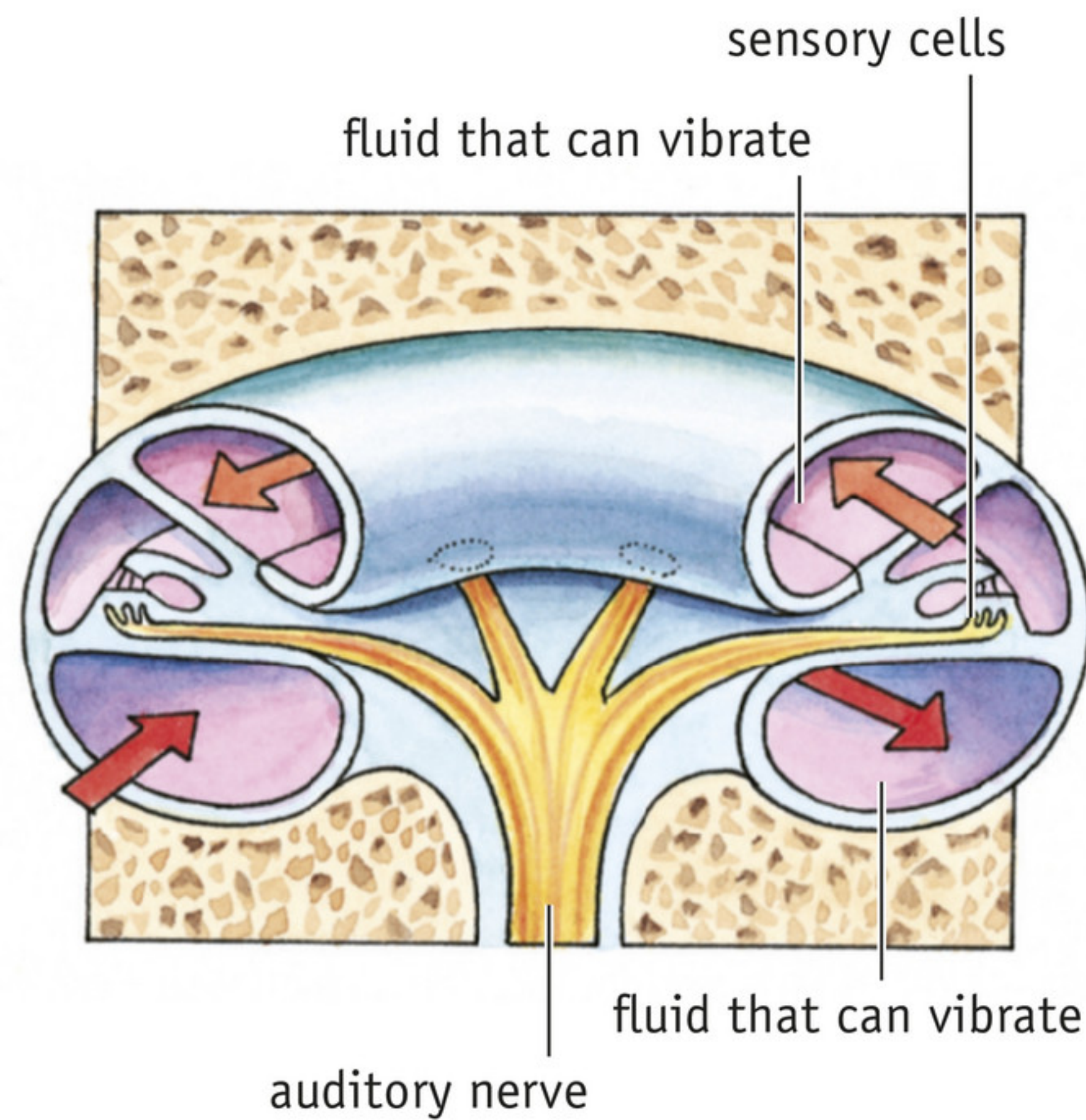
The eardrum makes the ossicles vibrate. The ossicles pass the vibrations on to the oval window in the cochlea. The cochlea consists of three chambers that are rolled up into a spiral. All three chambers are filled with a fluid. One of these chambers starts at the oval window that is connected to the stirrup. If the ossicles make the oval window vibrate, the fluid in the chambers of the cochlea starts to vibrate too.

► **Fig. 16** Ossicles.



The middle of the three chambers contains **sensory cells** (see figure 17). They are stimulated by the vibrations of the fluid. This produces impulses in the sensory cells. The sensory cells are connected to the **auditory nerve**, which transmits the impulses to the brain.

► **Fig. 17** Chambers of the cochlea (cross section, schematic).

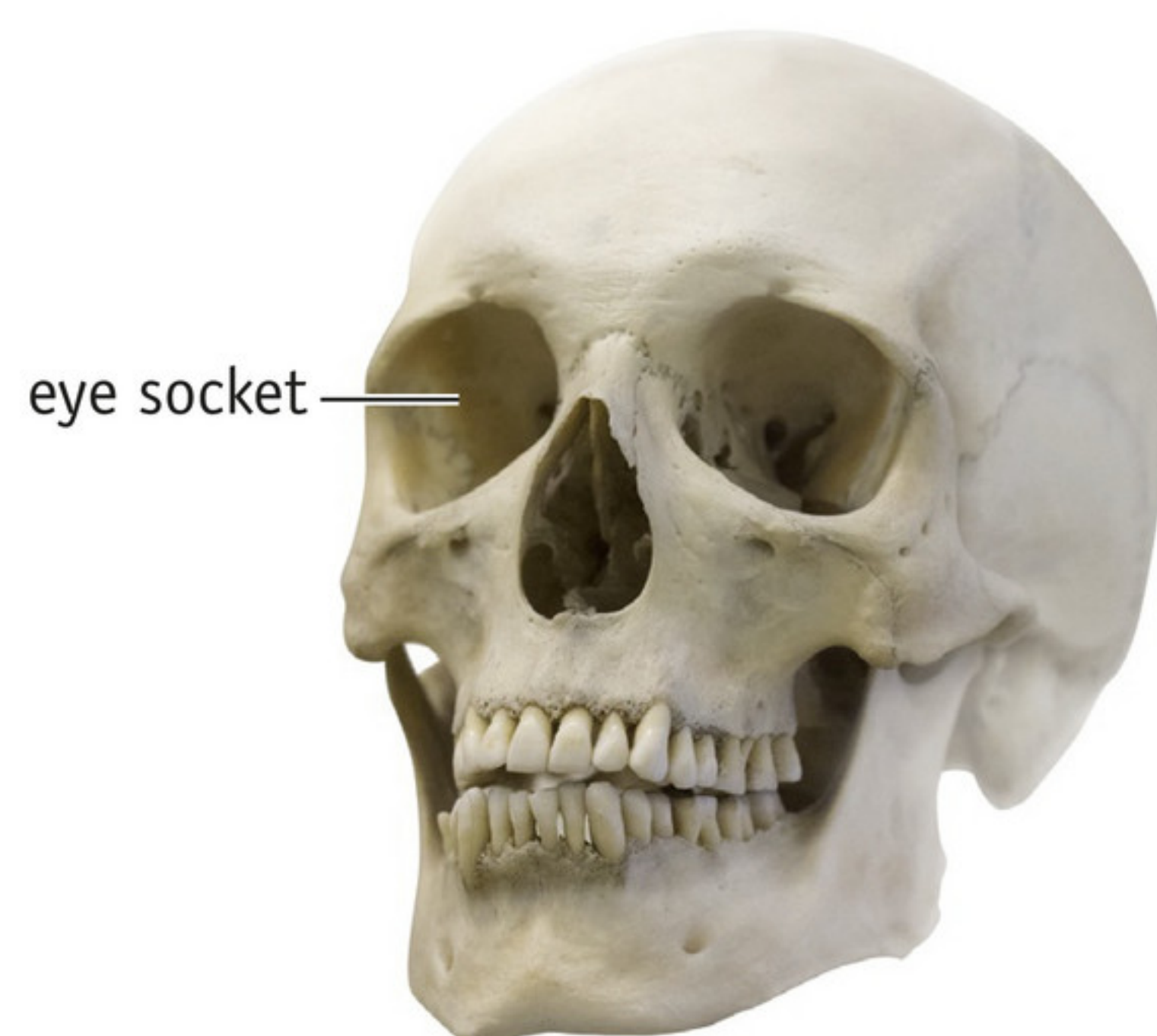


The middle ear is connected to the back of the throat via the **Eustachian tube**. The walls of the Eustachian tube are usually pressed together. Certain movements (swallowing, yawning) will make the Eustachian tube open up. This lets air flow from the back of the throat into the middle ear, or the other way round. The air pressure on both sides of the eardrum will then be equalised. This is needed if the eardrum is to vibrate properly.

WB EXERCISES 14 TO 16, PAGE 54

5 The eyes

▼ Fig. 18



The receptors for **sight** are found in the eyes. Your eyes are vulnerable organs, so they are well protected in your eye sockets (see figure 18). The **eyebrows** make sure that sweat or other moisture runs along past the eyes and not into them. The **eyelashes** protect the eyes against dirt and excessively bright light.

THE EXTERNAL STRUCTURE OF THE EYE

The white part of the eye is called the **sclera**. This is a tough membrane that protects the eye. The coloured part of the eye is called the **iris**. The iris has an opening called the **pupil**. The pupil looks like a round black spot. The **cornea** covers the iris and the pupil (see figure 19.2).

Underneath the skin above the eyes are the **tear glands**. These produce **tears**. Blinking makes the **eyelids** spread the tears across the eyes. The fluid in tears protects the eyes against dehydration and cleans them. It rinses away small particles of dust or irritating substances. You notice this when you smell an onion, for instance. The smell of the onion stimulates the sensory cells in the cornea. As a result, the tear glands receive impulses from nerve cells and start to produce more tears. The corners of the eyes have two small openings. Here the tears drain into the **tear ducts**, which discharge into the nasal cavity.

WB EXERCISES 17 AND 18, PAGE 56

▼ Fig. 20



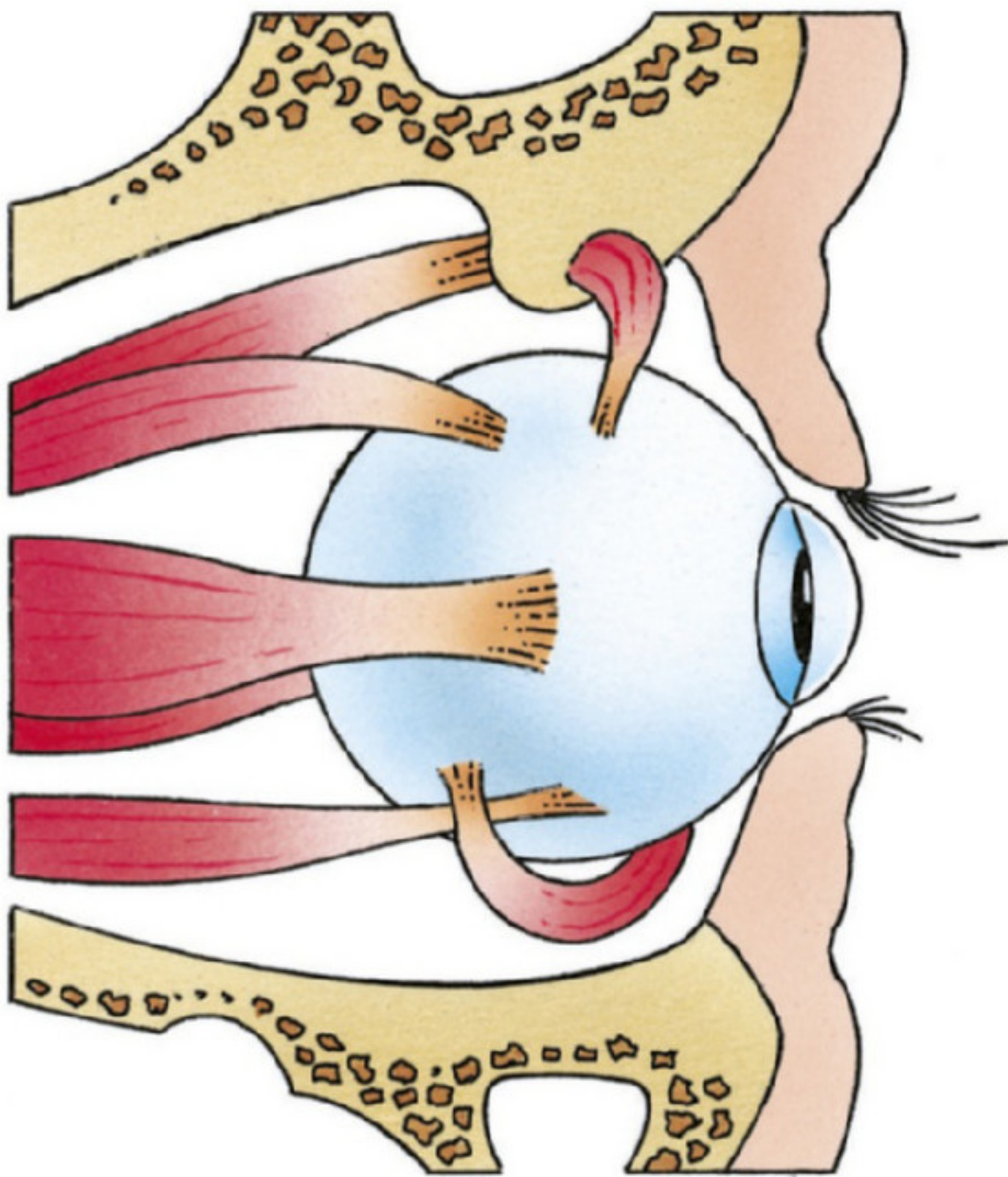
▼ Fig. 19 An eye.



1 front view

2 side view

▼ Fig. 21 Eye muscles.

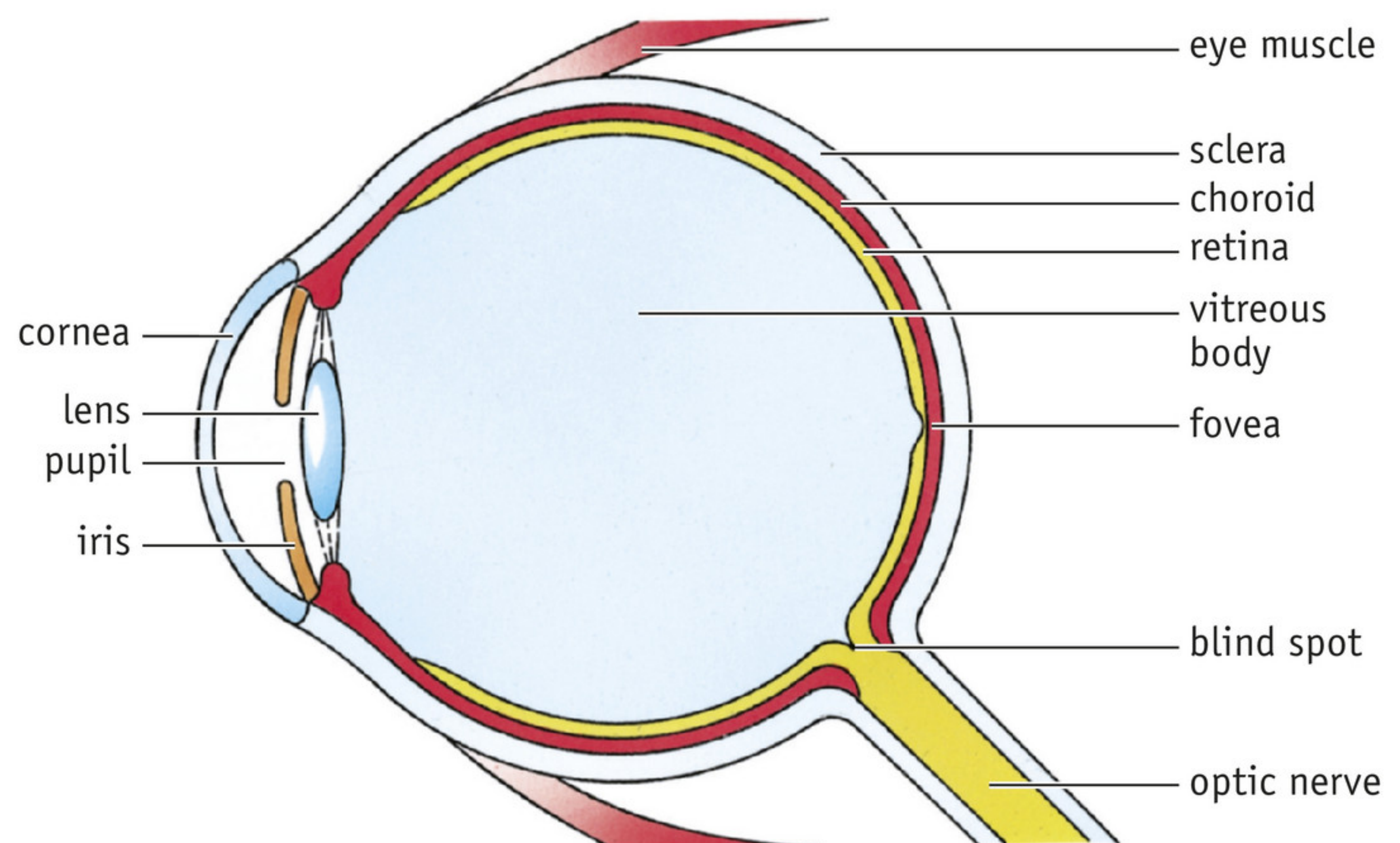


THE INTERNAL STRUCTURE OF THE EYE

Both eye sockets have various **eye muscles** on the left, right, at the top and bottom that are attached to the sclera (see figure 21). The eye muscles can rotate the eyes in any desired direction.

Figure 22 shows a schematic drawing of a cross section of an eye. Most of the eyeball is filled with a jelly-like mass: the **vitreous body**. The wall of an eye consists of three layers. The outermost layer is the **sclera**, which is white in colour. At the front of the eye, the sclera gives way to the **cornea**. The cornea is transparent, so that light can get into the eye.

▼ Fig. 22 An eye (cross section).



The middle layer is the **choroid**. This layer contains a lot of blood vessels. The choroid provides the nutrients for most of the eye. At the front of the eye, the choroid becomes the **iris**. The **pupil** is the opening in the iris. The pupil lets light get into the eye.

The innermost layer of the wall of an eye is called the **retina**. It contains the sensory cells. They are stimulated when light falls onto them. This produces impulses in the sensory cells. The **optic nerve** transmits the impulses to the brain.

In the centre of the retina is the **fovea**. The sensory cells in the fovea let you see most sharply. If you are looking at something, you rotate your eyes so that you are basically looking at it with the fovea. The part of the retina where the optic nerve leaves the eye is called the **blind spot**. There are no sensory cells on the blind spot. The retina is kept in place by the vitreous body.

Behind the iris and the pupil is the **lens**. The lens makes sure that you can see sharply.

WB EXERCISES 19 TO 22, PAGE 57

▼ **Fig. 23** Iris and pupil.

1 when bright light enters the eye



2 with less light entering the eye

THE PUPILLARY LIGHT REFLEX

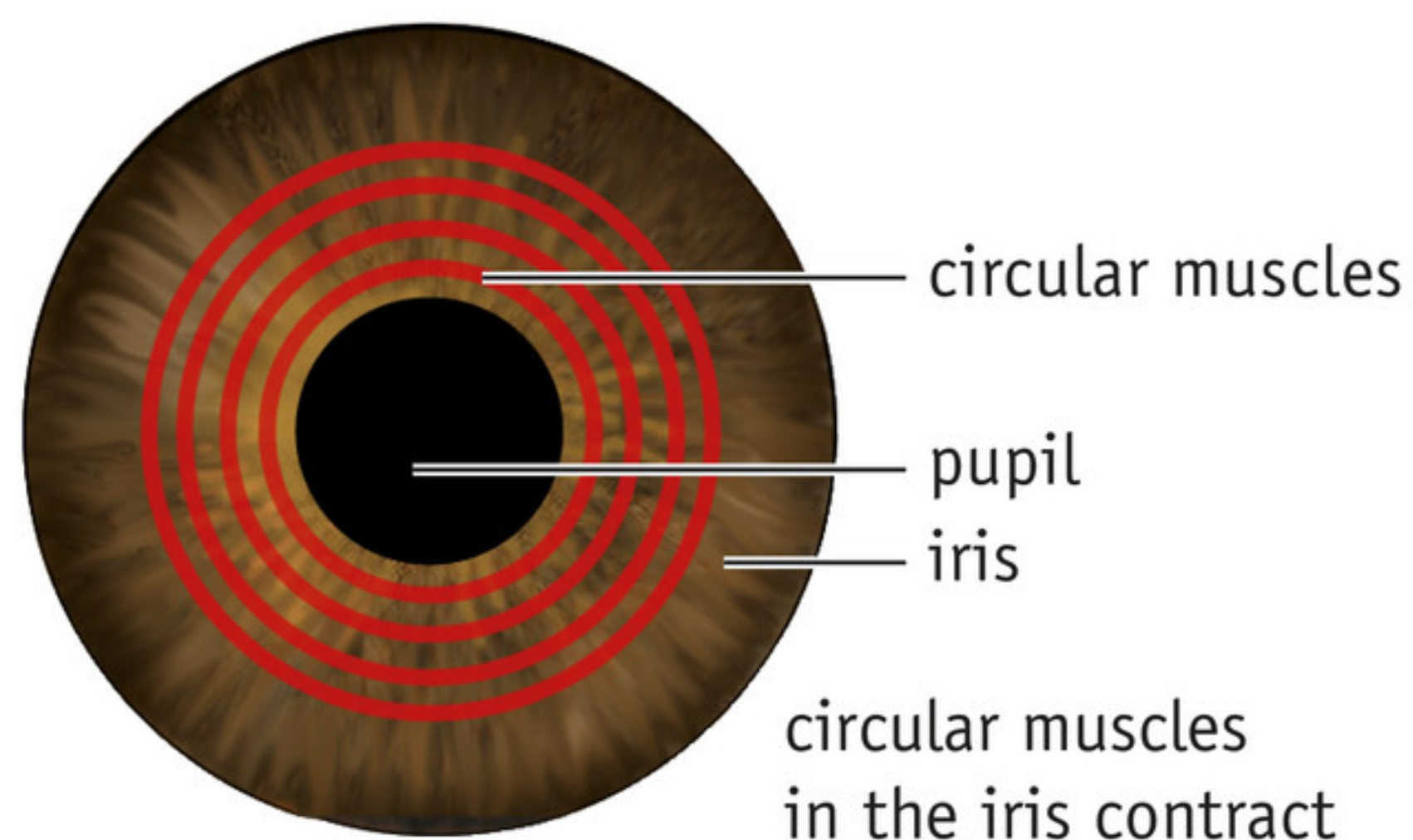
The amount of light that your eyes receive is not always the same. If very bright light enters your eyes, the sensory cells in the retina could be damaged. That is why you should never look straight into the sun. You have learned that the eyelashes protect your eyes against light that is too bright. Bright light makes you squeeze your eyes almost shut. The sensory cells in the retina are also protected against bright light because the size of the pupil changes. This is known as the **pupillary light reflex**.

The pupillary light reflex regulates the amount of light that falls onto the retina. If bright light enters your eyes, the iris becomes larger (see figure 23.1). This reduces the size of the pupil. A small pupil lets less light through. This protects the sensory cells in the retina against bright light.

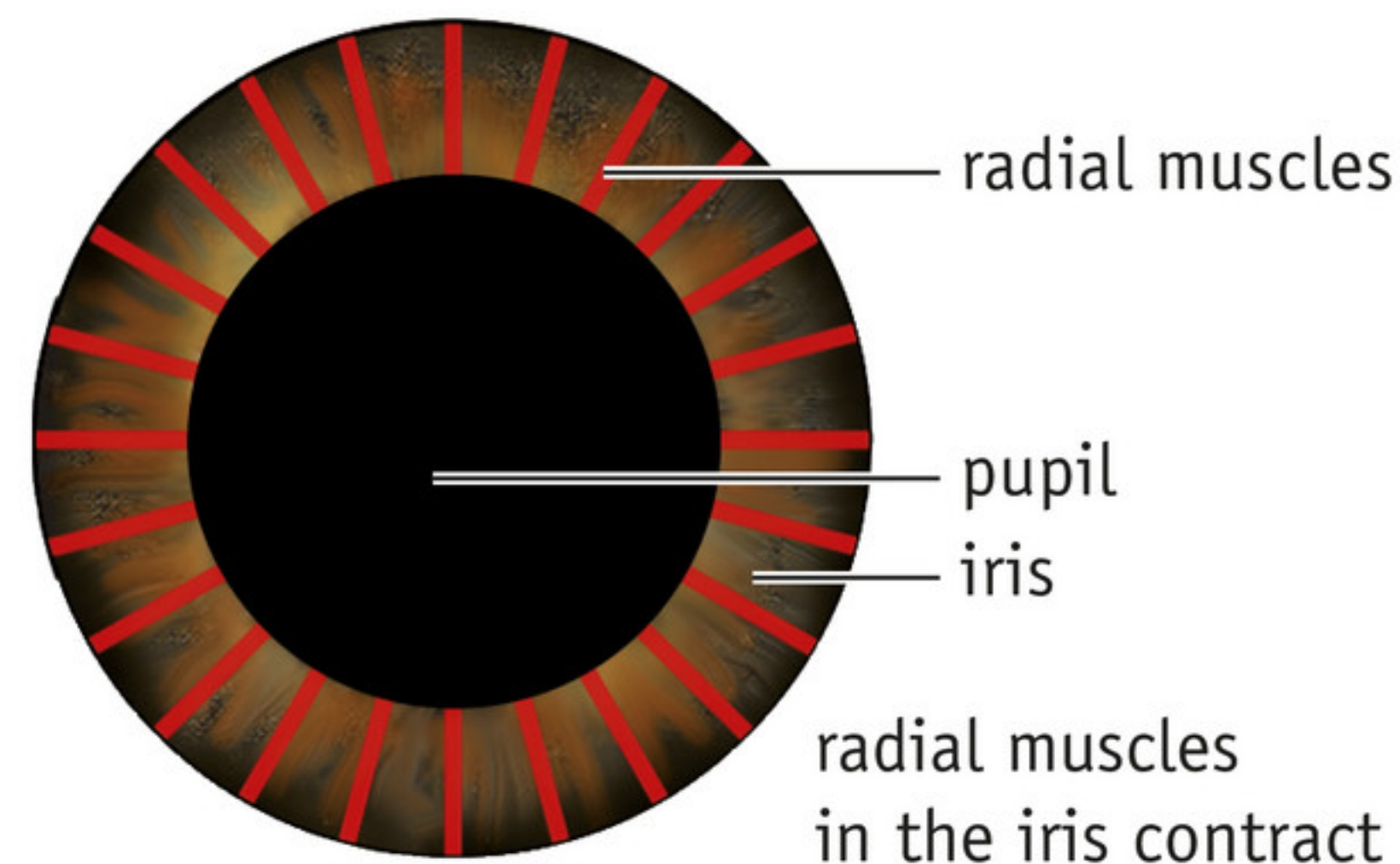
If the light entering your eyes is dim, the iris will become small (see figure 23.2). The pupil then gets larger. A large pupil lets a lot of light through. This lets you see even when it is almost dark.

The muscles in the iris let the pupil get larger and smaller. The iris has circular muscles and radial muscles. The **circular muscles** are around the pupil. When they contract, the pupil becomes smaller. The **radial muscles** run from the pupil to the outside edge of the iris. When they contract, the pupil becomes larger (see figure 24). An optometrist uses eye drops to block the pupillary reflex so that he can examine the retina and the choroid properly (see figure 25).

WB EXERCISES 23 AND 24, PAGE 60

▼ **Fig. 24** Muscles in the iris (schematic).

1 bright light: the circular muscles constrict the pupil



2 dim light: radial muscles dilate the pupil

▼ Fig. 25

Optometrist

Hello. I'm Otto. I work as an optometrist at a hospital, where I do ophthalmological research and make measurements. I perform checks to see if someone has cataracts, for example. The lens of an eye with a cataract has become cloudy.

Many patients are given eye drops to make sure that the pupil stays dilated, even when a lot of light enters the eye. A dilated pupil lets me have a good look at the retina and the choroid using a slit lamp (see figure 25.1). The capillaries in the choroid can get damaged in people who have diabetes. The sensory cells then do not function properly anymore and these people may have poorer vision or even go blind. It is important that this is detected in good time. I take photos of the choroid (see figure 25.2) of people with diabetes, after which the ophthalmologist takes a closer look at the pictures.

Certain eye conditions can damage the optic nerve. The slit lamp lets you see part of the optic nerve, so that damage can be detected in good time.

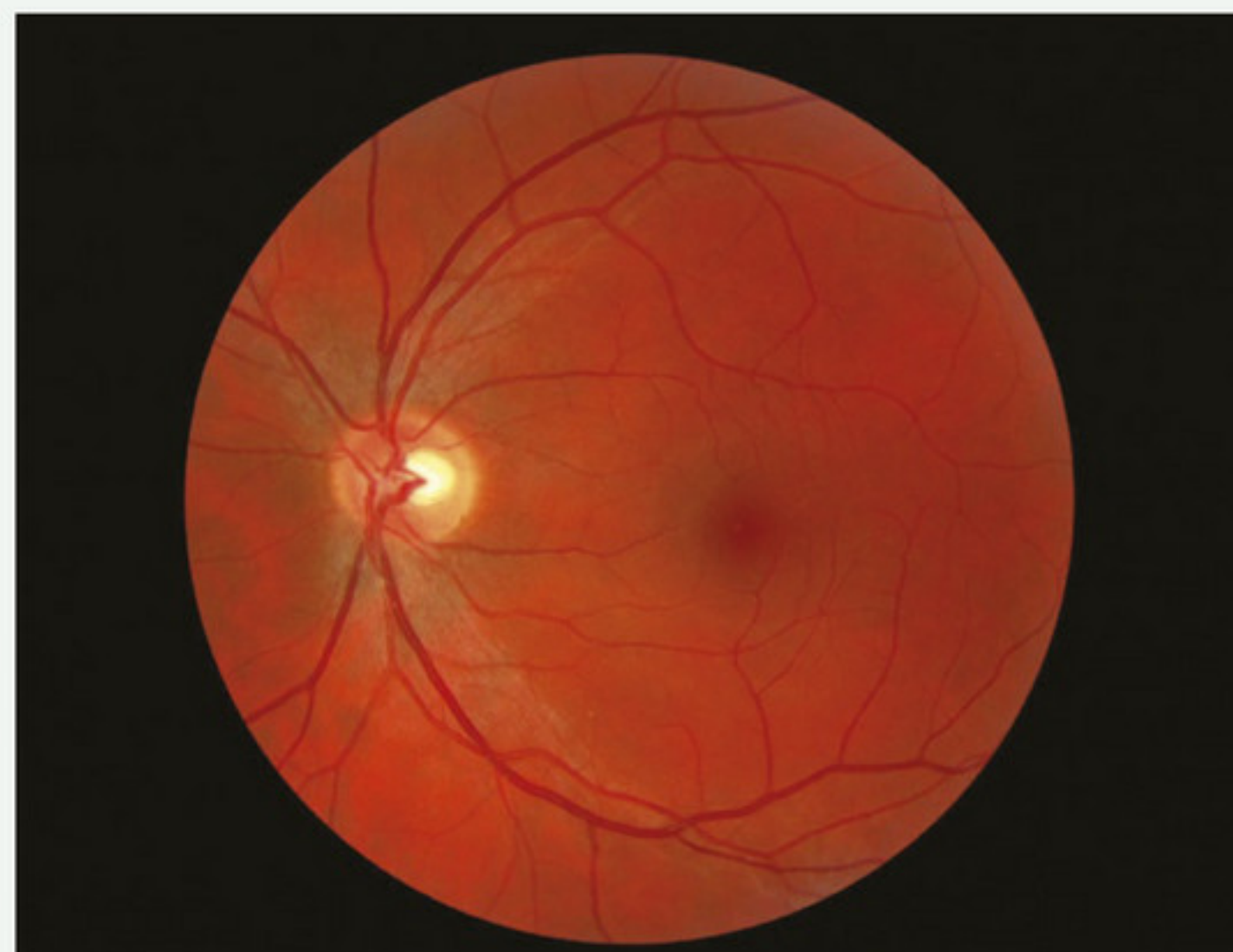
Many people wear contact lenses (see figure 25.3). Contact lenses are worn on the cornea. Most people do not have perfectly spherical corneas. Measuring the shape of the cornea means that contact lenses can be tailored to fit perfectly.

To become an optometrist, you have to take an optometry degree course.

I like this job. You work with so many different people and with equipment that you have to handle accurately.



1



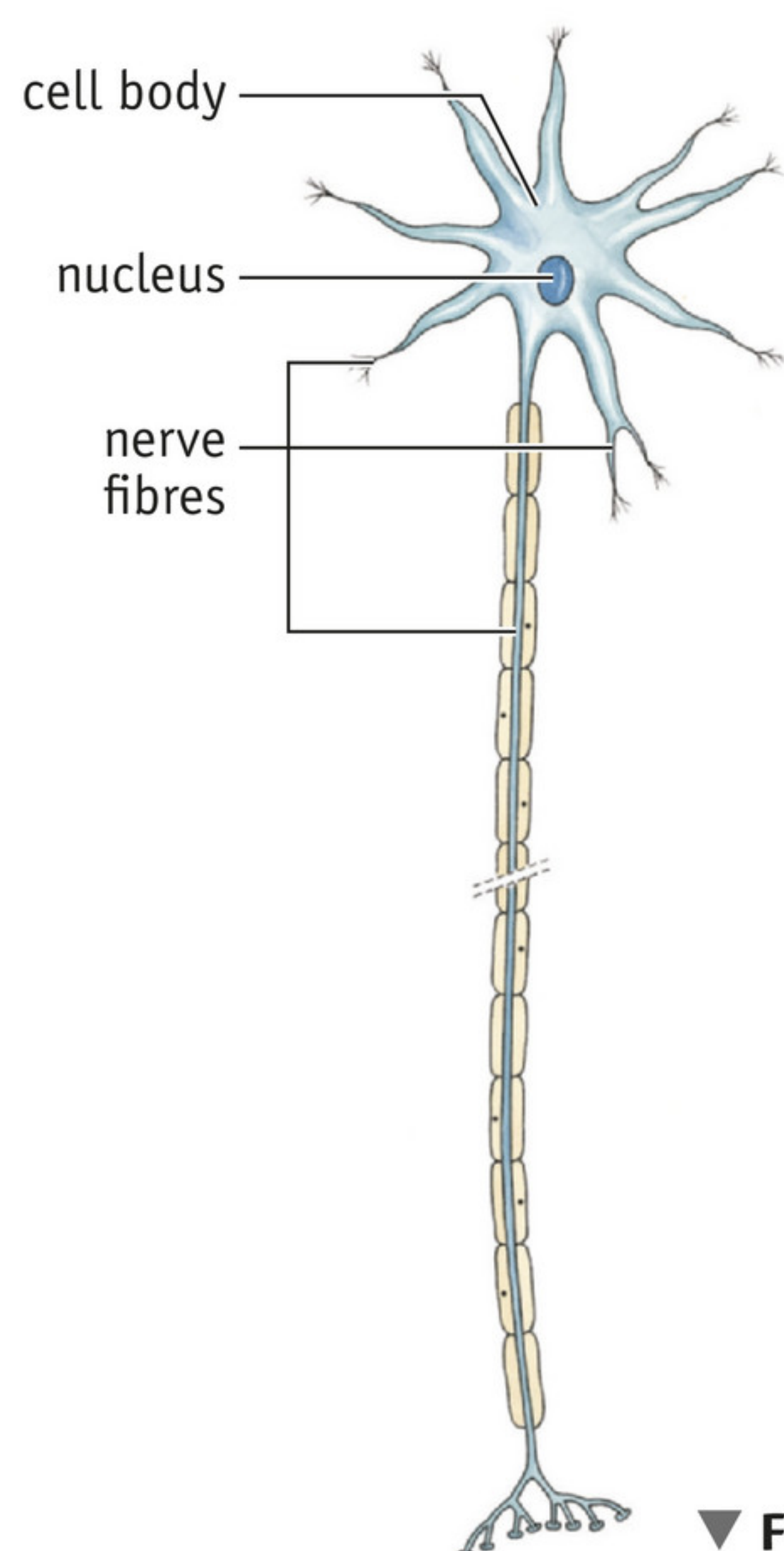
2



3

6 The nervous system

▼ **Fig. 26** A nerve cell.



You have learned that impulses can be produced in sensory cells. These impulses are passed on to the brain via the nerves. The nerves and the brain are part of the nervous system.

The nervous system contains millions of **nerve cells**. Each nerve consists of a cell body and its processes called nerve fibres (see figure 26).

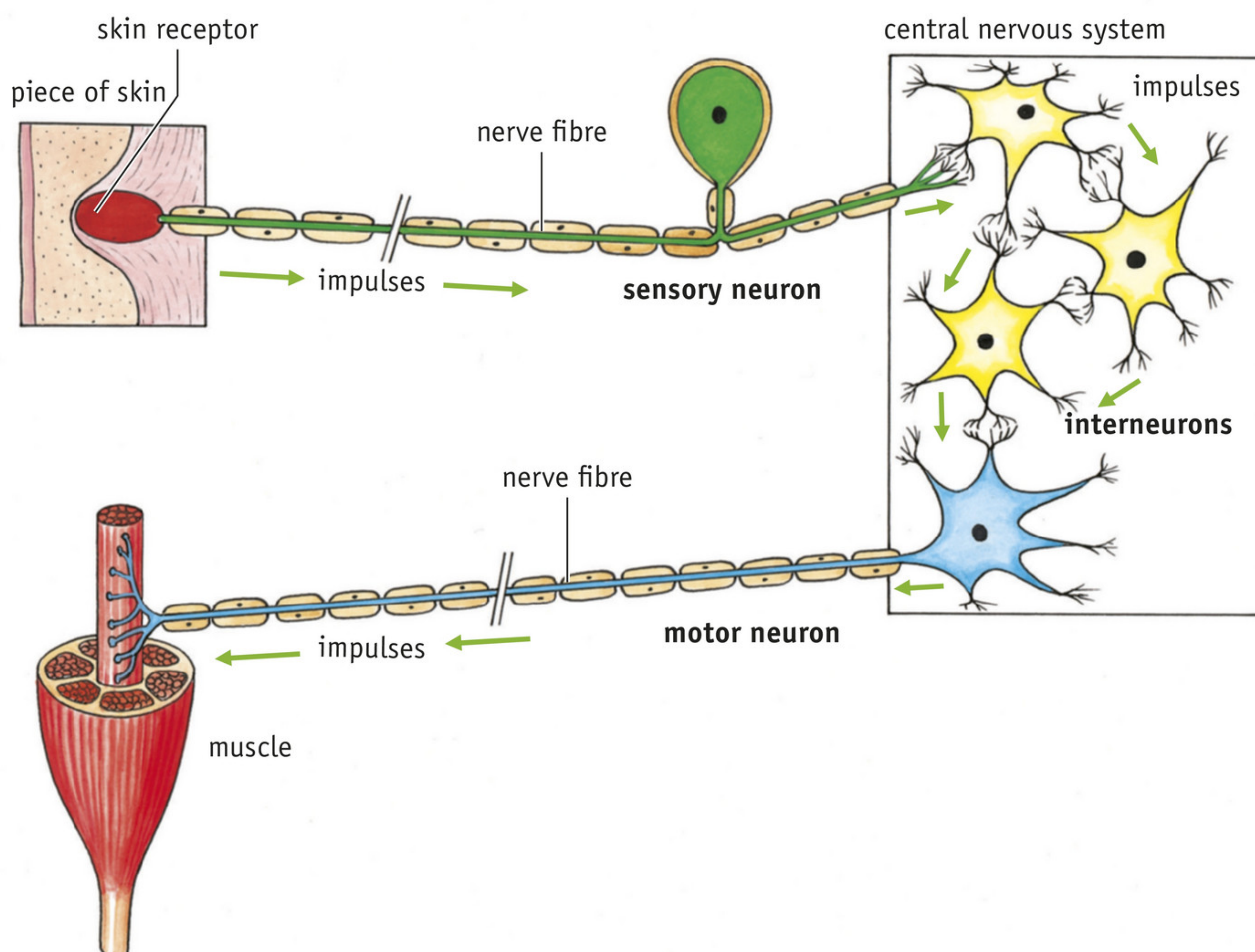
The **cell body** of a nerve cell is the part that contains the nucleus. The cell bodies of nerve cells are in or near the central nervous system.

The **nerve fibres** conduct the impulses. There are nerve fibres that conduct impulses towards the cell body and nerve fibres that conduct impulses away from the cell body. Nerve fibres can also pass the impulses to other cells or nerve cells. Nerve fibres can be very long.

Three types of nerve cell can be distinguished: sensory neurons, motor neurons and interneurons (see figure 27).

Sensory neurons carry the impulses from the sense organs to the central nervous system. The cell bodies of nerve cells are near the central nervous system. A sensory neuron has a single long nerve fibre, which carries impulses into the cell body. Sometimes this nerve fibre can be as much as a metre long, for instance in a sensory neuron that carries impulses from a sensory cell in the toe to the cell body near the spinal cord.

▼ **Fig. 27** Types of nerve cells.



Motor neurons carry impulses from the central nervous system to muscles or glands (see figure 27). The cell bodies of motor neurons are *in* the central nervous system. A motor neuron has a single long nerve fibre (sometimes up to a metre long) that carries impulses away from the cell body.

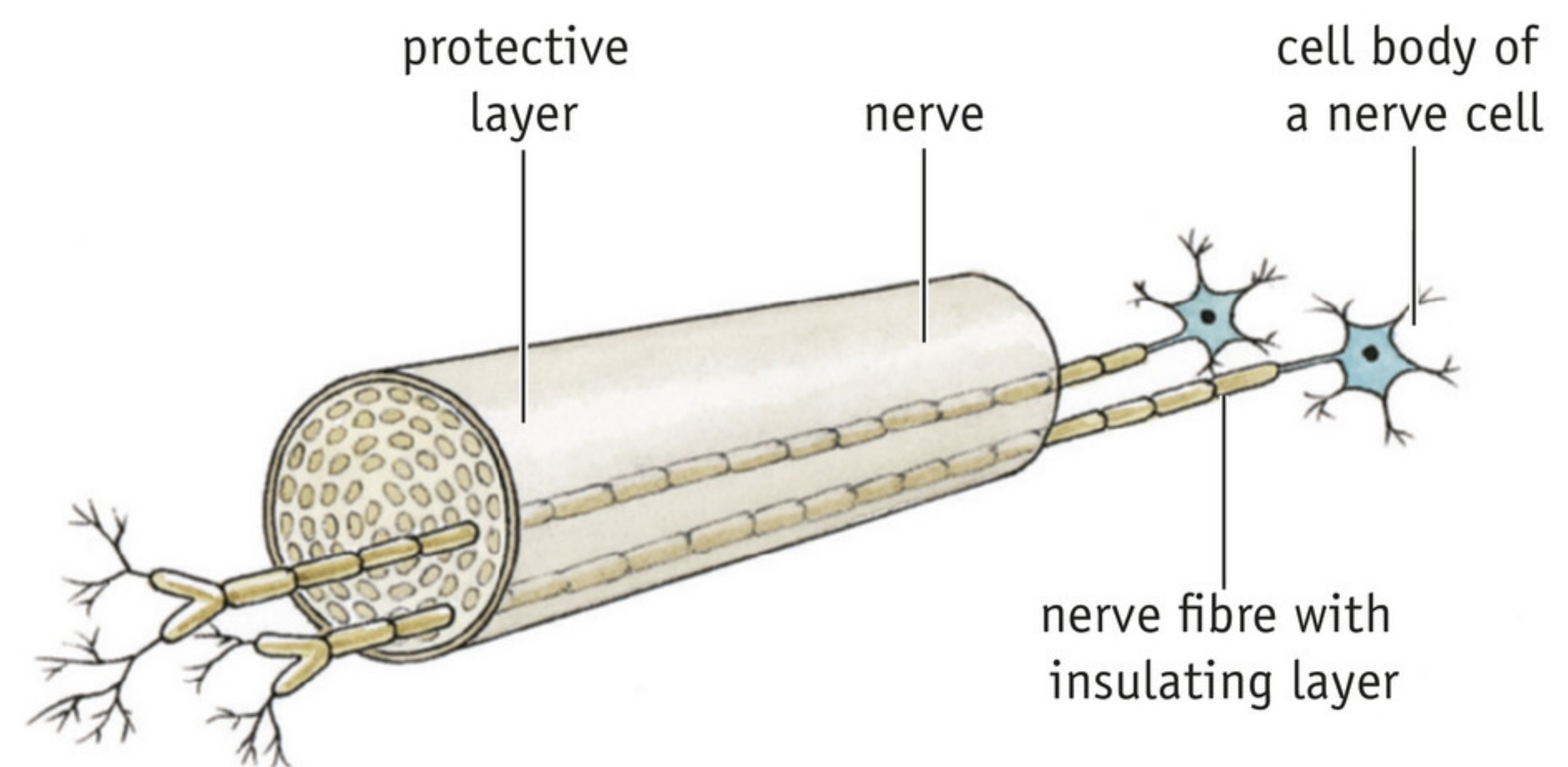
Interneurons conduct impulses within the central nervous system. They connect the nerve fibres of sensory neurons to the nerve fibres of motor neurons (see figure 27). Interneurons are located *entirely within* the central nervous system. Interneurons are connected to each other by axons.

WB EXERCISES 25 AND 26, PAGE 62

NERVES

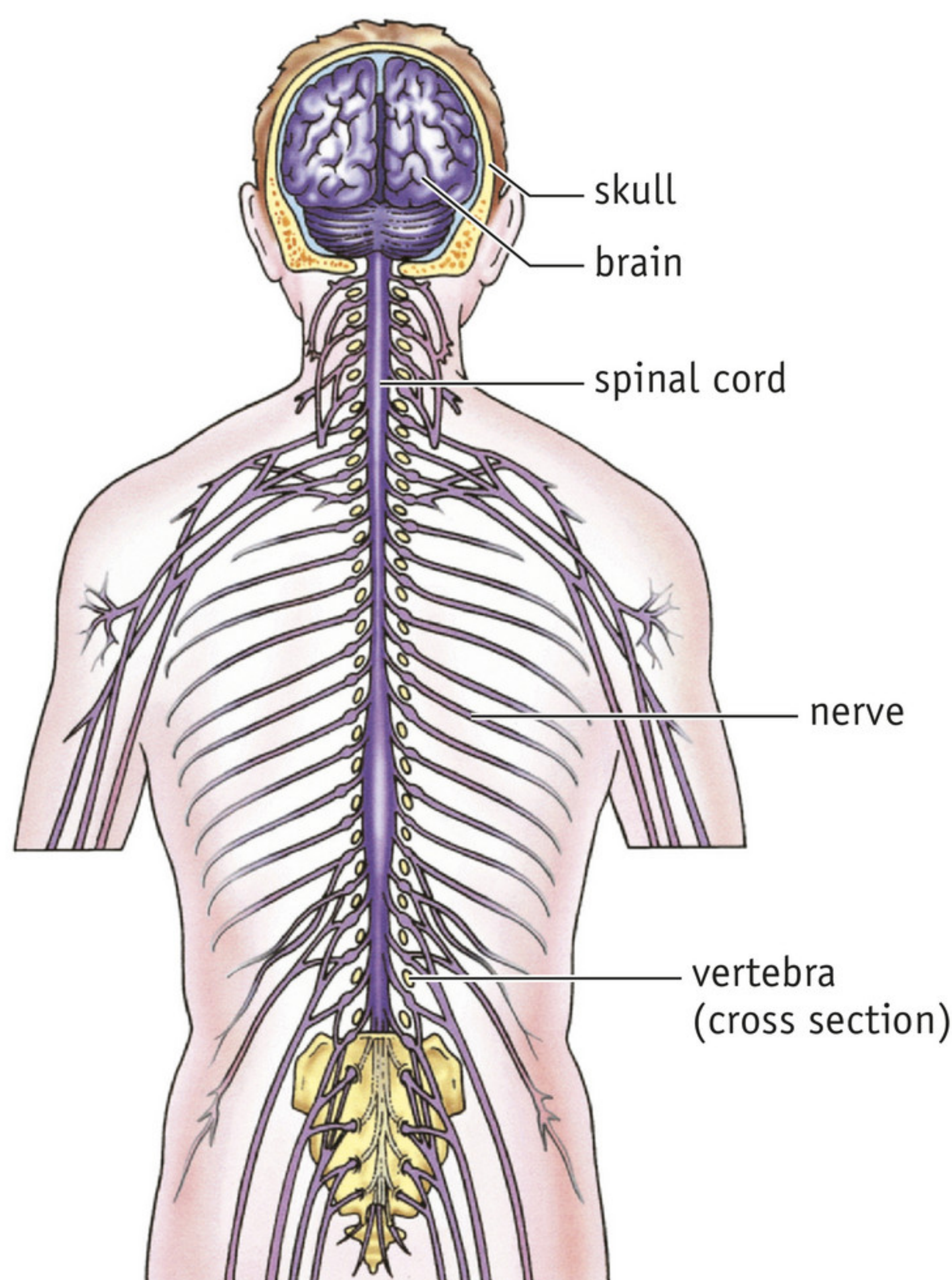
In reality, a single impulse is never passed to the central nervous system or to a muscle or gland via just one nerve fibre. In reality, impulses are passed via thousands of nerve fibres at the same time. The nerve fibres are found together in a **nerve** (see figure 28). Each nerve fibre in a nerve is surrounded by a thin layer. This layer insulates the nerve fibres from each other. A nerve has a tough protective layer around it.

▼ **Fig. 28** Nerve with a number of nerve cells (schematic).

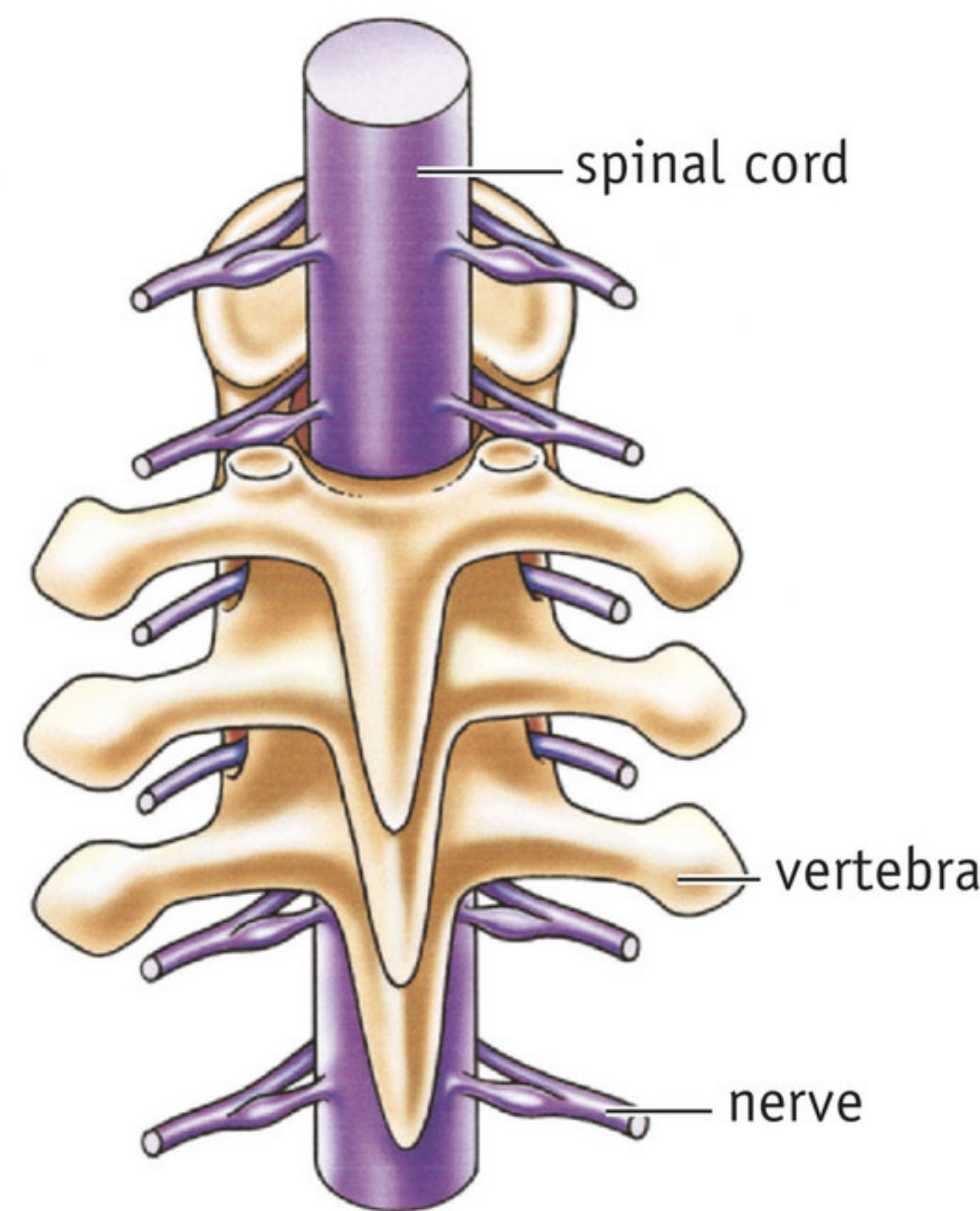


The nerves connect the central nervous system to all parts of the body. Body parts in the head and the neck are connected directly to the brain by nerves. The torso and limbs are connected to the spinal cord by nerves (see figure 29). Impulses are passed to the brain via the spinal cord. The spinal cord starts at the brain and ends in the lumbar vertebrae in the lower back. The spinal cord is surrounded by the vertebrae of the vertebral column (see figure 30).

▼ **Fig. 29** Body parts in the torso and limbs are connected to the spinal cord by nerves.



▼ Fig. 30 Location of the spinal cord in the spine.



Nerves can be very long, sometimes as much as a metre. The impulses then have to cover large distances through the nerves. Even so, you are able to react very quickly. The impulses are conducted through the nervous system at high speeds. If a nerve gets constricted, you will feel a strange tingling sensation (see figure 31).

WB EXERCISE 27, PAGE 63

▼ Fig. 31

What is the matter when your arm or leg ‘goes to sleep’?

You wake up and you feel a strange tingling sensation in your arm or leg. You want to lift your arm, but you can't. As well as the strange ‘pins and needles’ sensation, you have no feeling in your arm or leg. Almost everyone has had this problem now and then. We say that the limb has ‘gone to sleep’. You have probably been lying on your arm or leg and blood vessels or nerves have been pinched. Once the pinching stops, the tingling sensation will disappear and you will be able to move your arm or leg as usual. Because that part of the body was constricted, impulses could no longer be transmitted properly. The lack of blood with fresh nutrients and oxygen also makes your arm or leg become weak and pale and you cannot move it very well for a while. The strange ‘pins and needles’ sensation is the observation in your brain that certain nerves are not carrying any impulses, whereas others are doing so a

great deal. The tingling sensation is a warning that you should change your position.

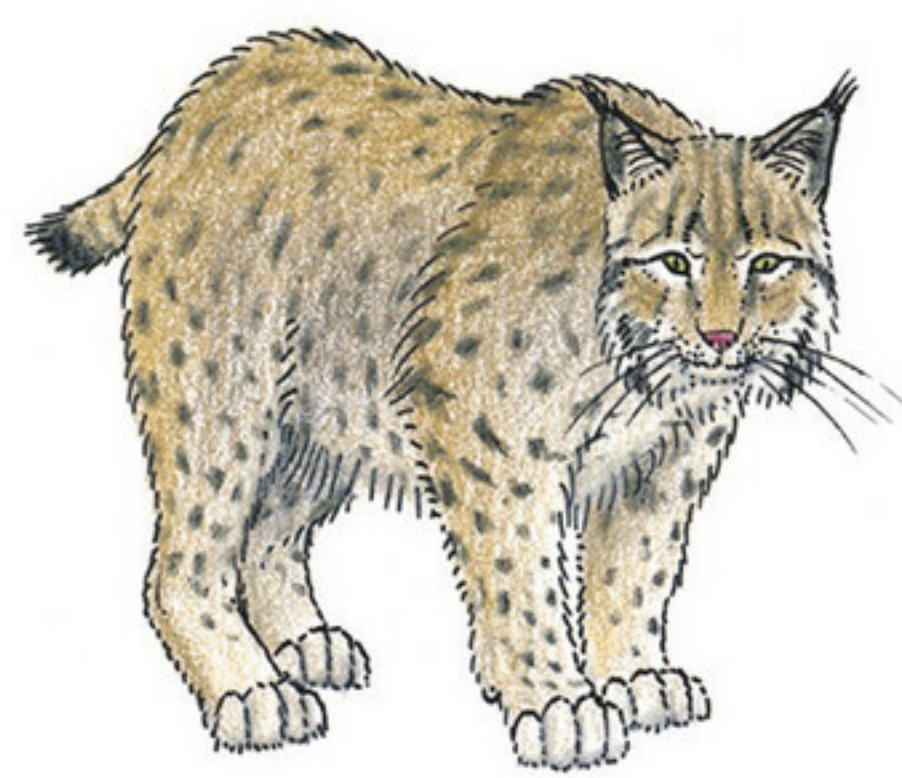


7 Behaviour

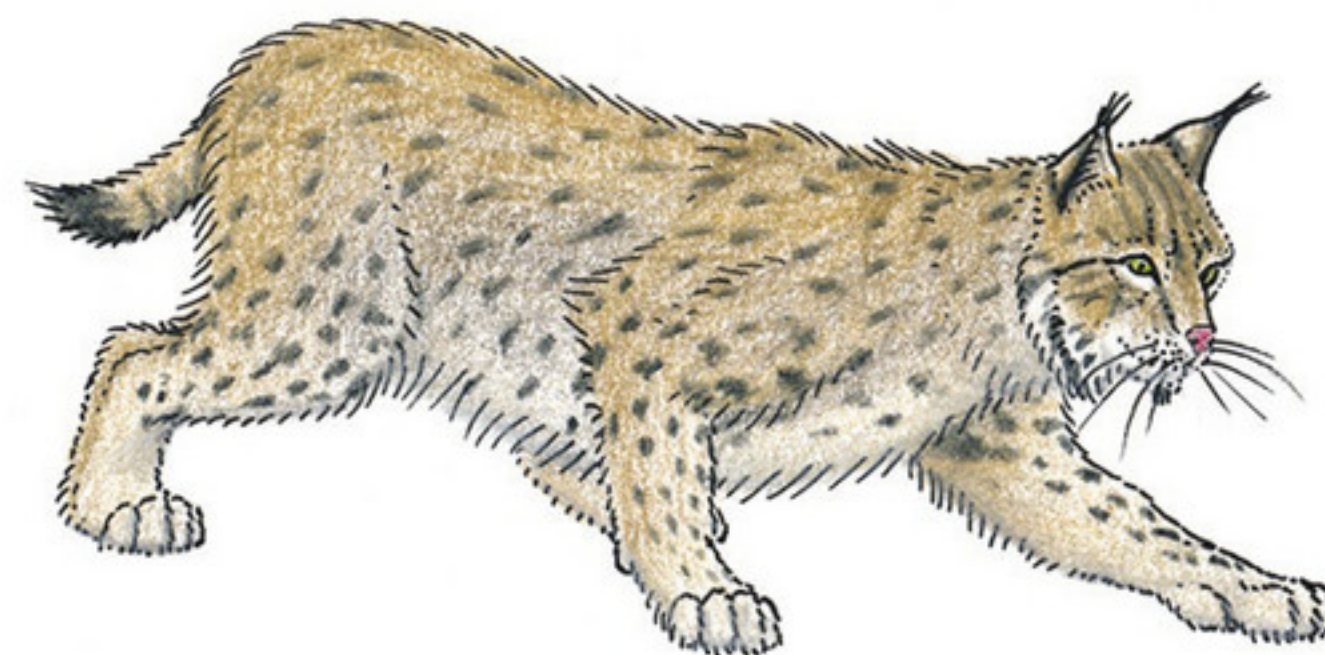
Everything that humans or animals do, such as laughing or looking at something, is **behaviour**. Making noises, sleeping, emitting scents and even standing still are examples of behaviour.

The behaviour of organisms consists of **actions** that are interrelated. Together, these actions have a purpose. In figure 32 you can see this in a lynx that is hunting. The hunting behaviour of the lynx consists of a series of actions such as stalking and sneaking up on the prey. The purpose of this hunting behaviour is eating to stay alive (self-regulation). The actions such as stalking, sneaking up on the prey and pouncing on it are often done in a fixed sequence. If the effect of one action leads to the next one, this is called a **behaviour chain**. The effect of stalking, for instance, is the detection of prey. This leads to the following action: sneaking up on it, and so on.

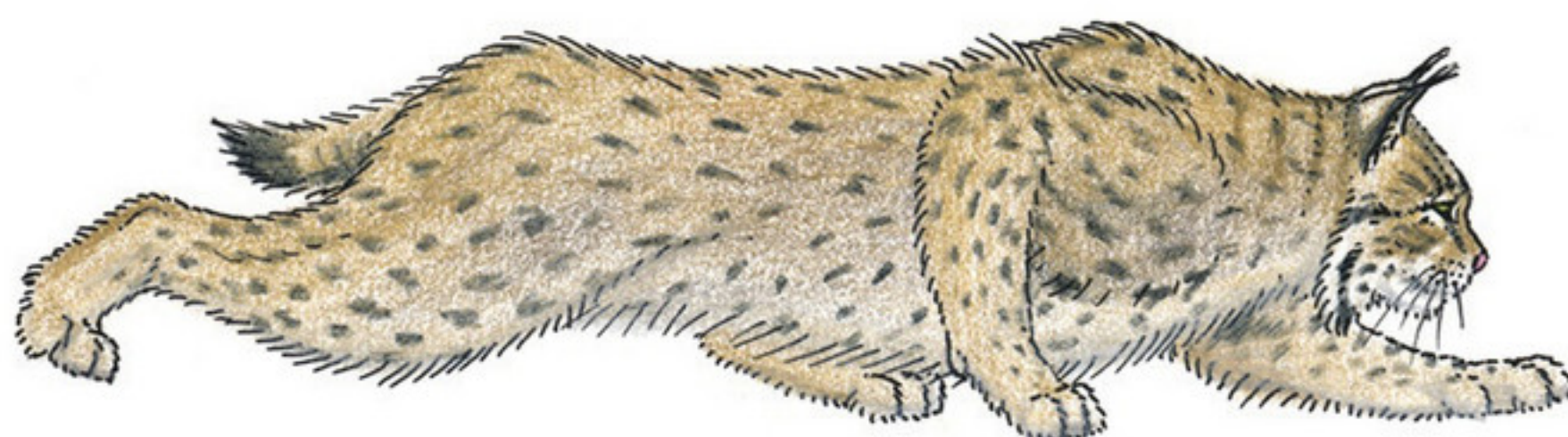
▼ **Fig. 32** The hunting behaviour of the lynx consists of a behaviour chain.



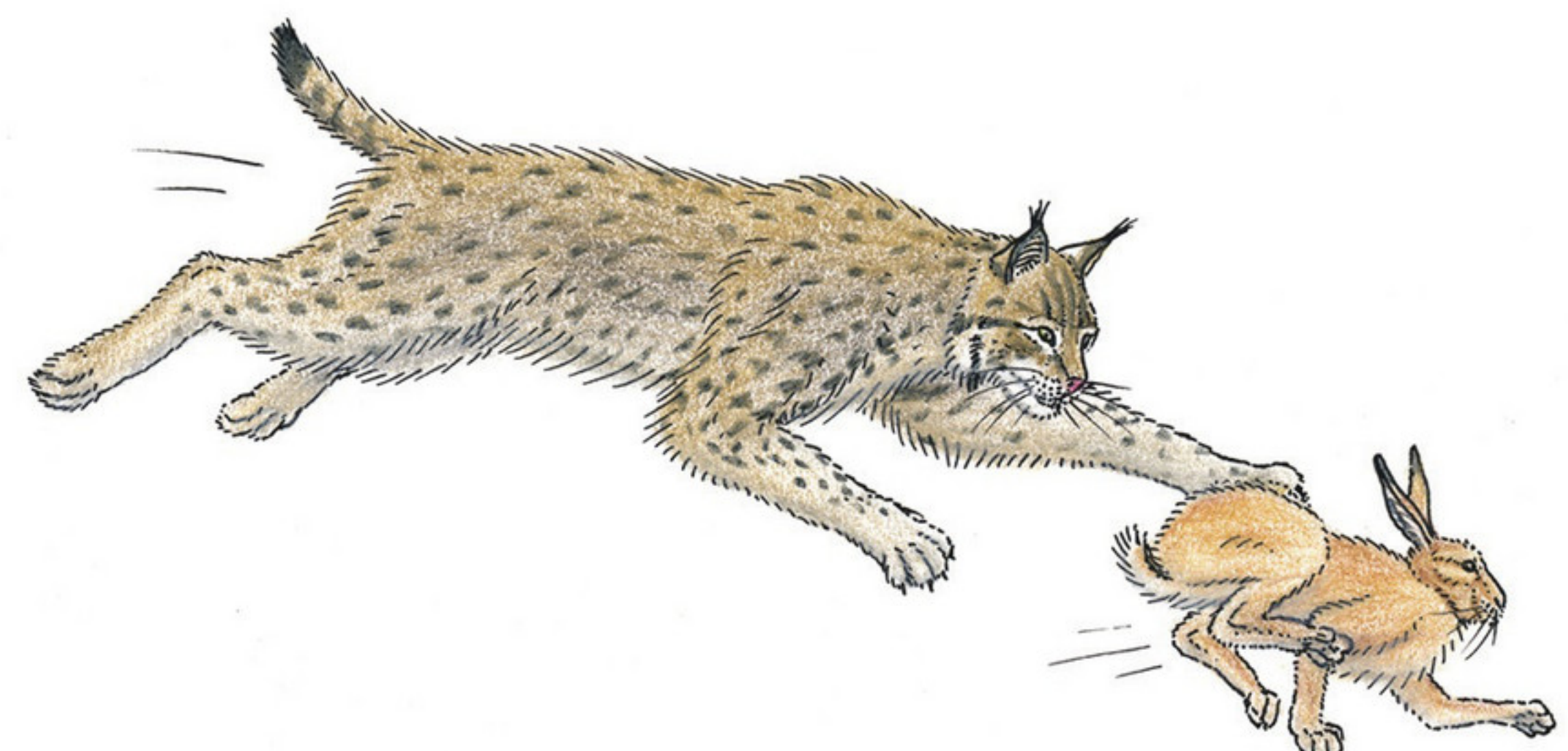
1 stalking



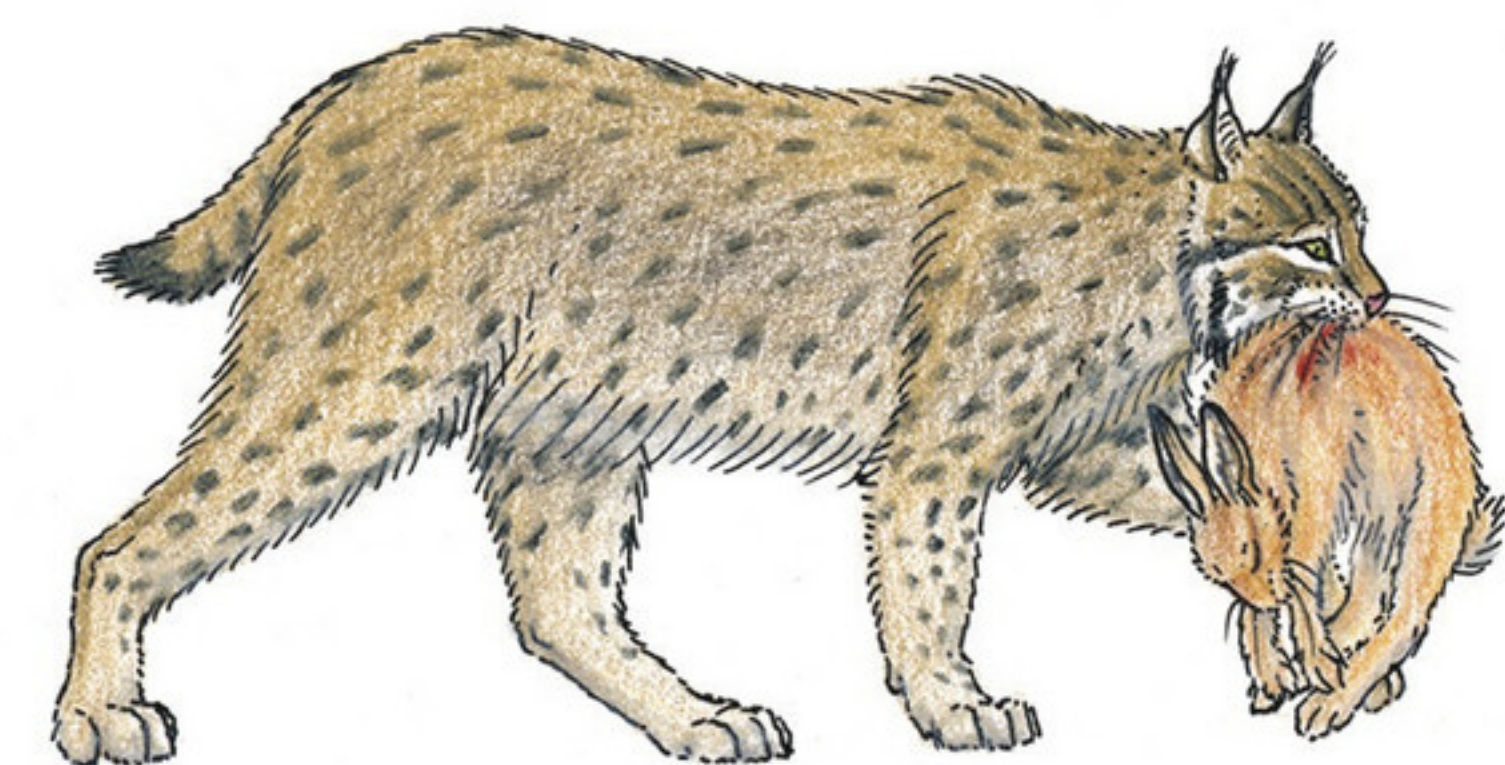
2 creeping closer



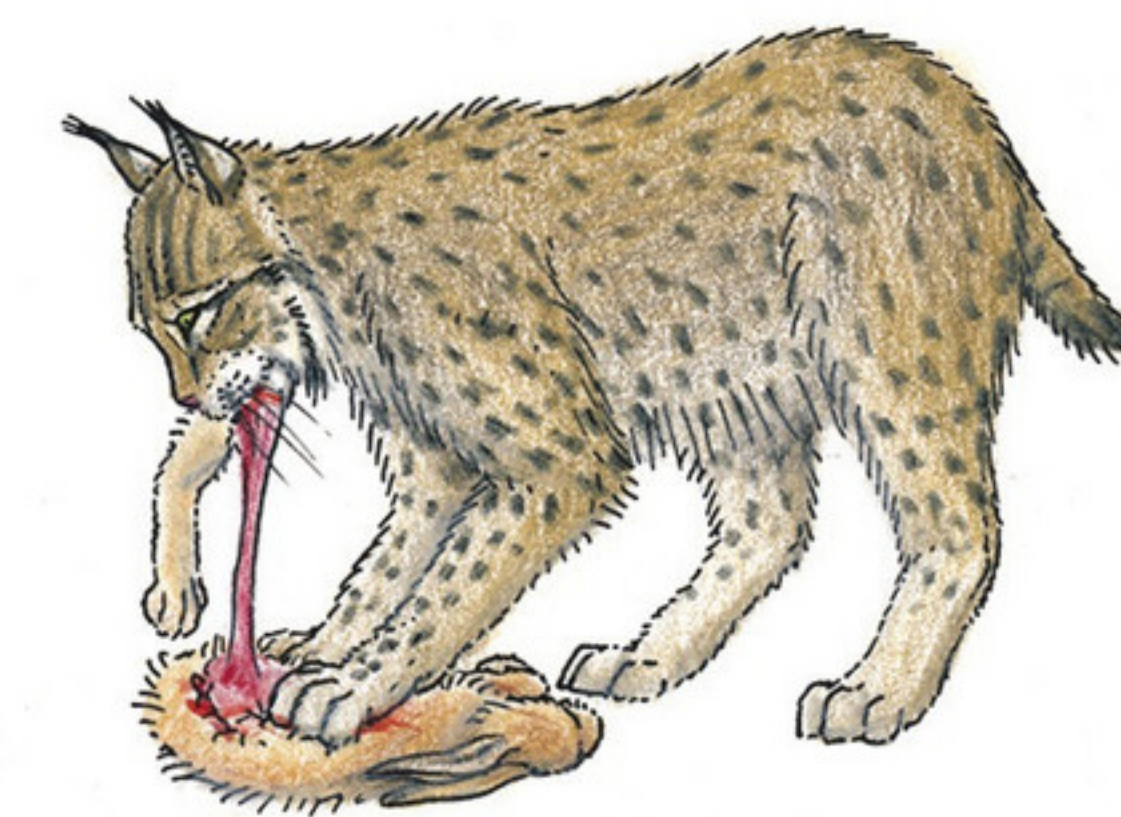
3 sneaking up on the prey



4 pouncing and killing



5 dragging the prey off

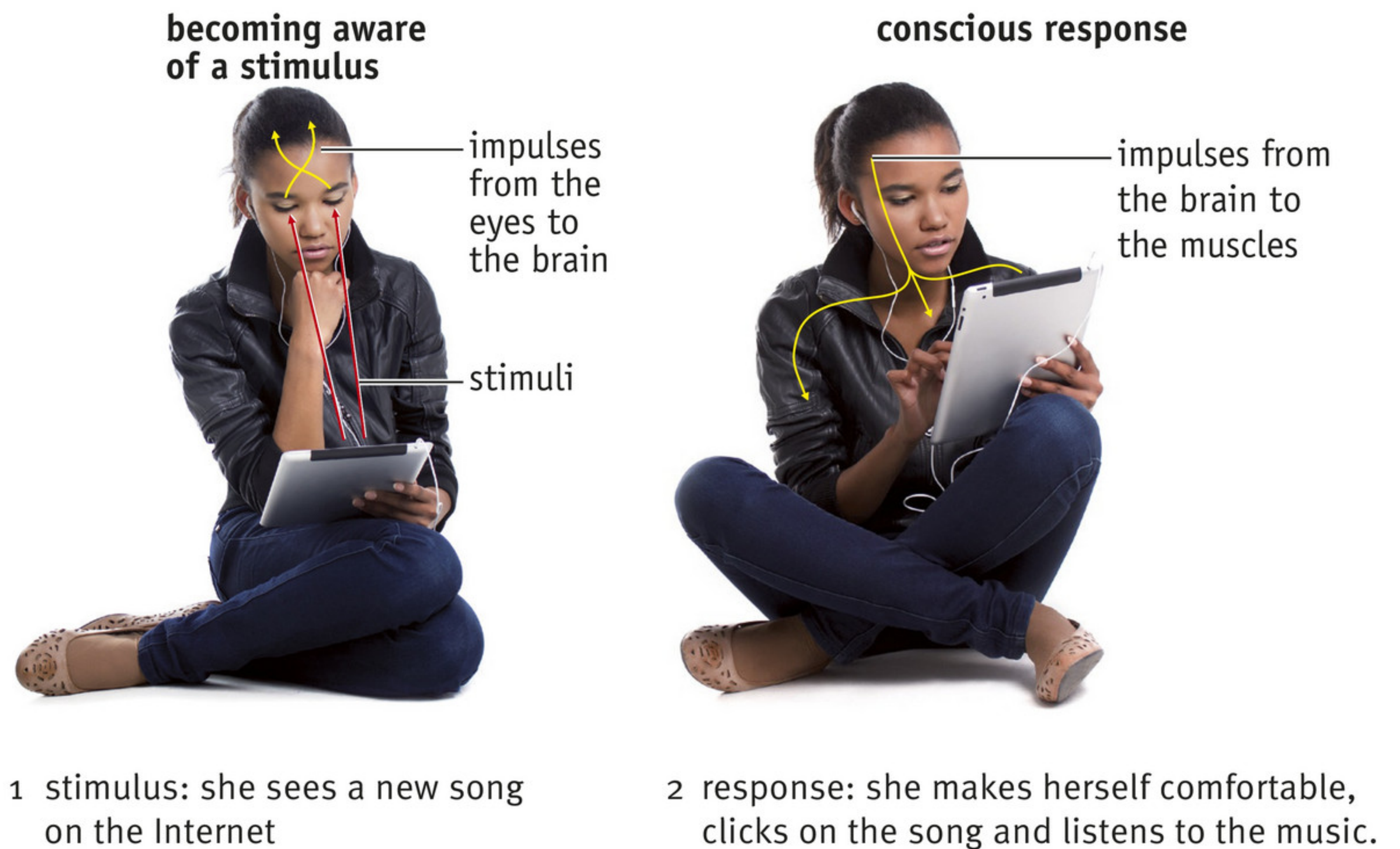


6 eating the prey

WHAT CAUSES BEHAVIOUR?

In Basics 1, you learned that a **stimulus** from the surroundings has an effect on an organism. You have also learned that sense organs respond to stimuli, causing impulses to go to your brain via nerves. You can see an example of this in figure 33. The girl sees a new song by her favourite group on the Internet. In her brain, she becomes consciously aware of this stimulus. She then responds to the stimulus: she makes herself comfortable, clicks on the song and listens to the music. For this, impulses are passed to her muscles. A reaction to a stimulus is called a **response**.

► **Fig. 33** Behaviour is a response to a stimulus.



▼ **Fig. 34** Motivation and stimuli are what cause behaviour.



There are various types of stimuli: you can get hungry and want to eat. Being hungry is a stimulus that is created *inside* the body. This is called an **internal stimulus**. There are also stimuli that come from *outside* the body: you smell freshly baked bread, for example. You can perceive these stimuli from outside the body through your senses; these are **external stimuli**.

The **motivation** is the willingness to perform certain behaviours (see figure 34). If you have already eaten a lot, your motivation to eat another sandwich will be very low. The stimulus of 'seeing a sandwich' will not lead to eating behaviour. But when you are hungry, your motivation to eat will be very high. The same stimulus of 'seeing a sandwich' will then lead to a response. If the stimulus is very strong and the motivation low, you can still show a response. You may not want another helping after eating a big meal, but you do still have an appetite for a delicious dessert with strawberries, ice cream and whipped cream. That still produces a response.

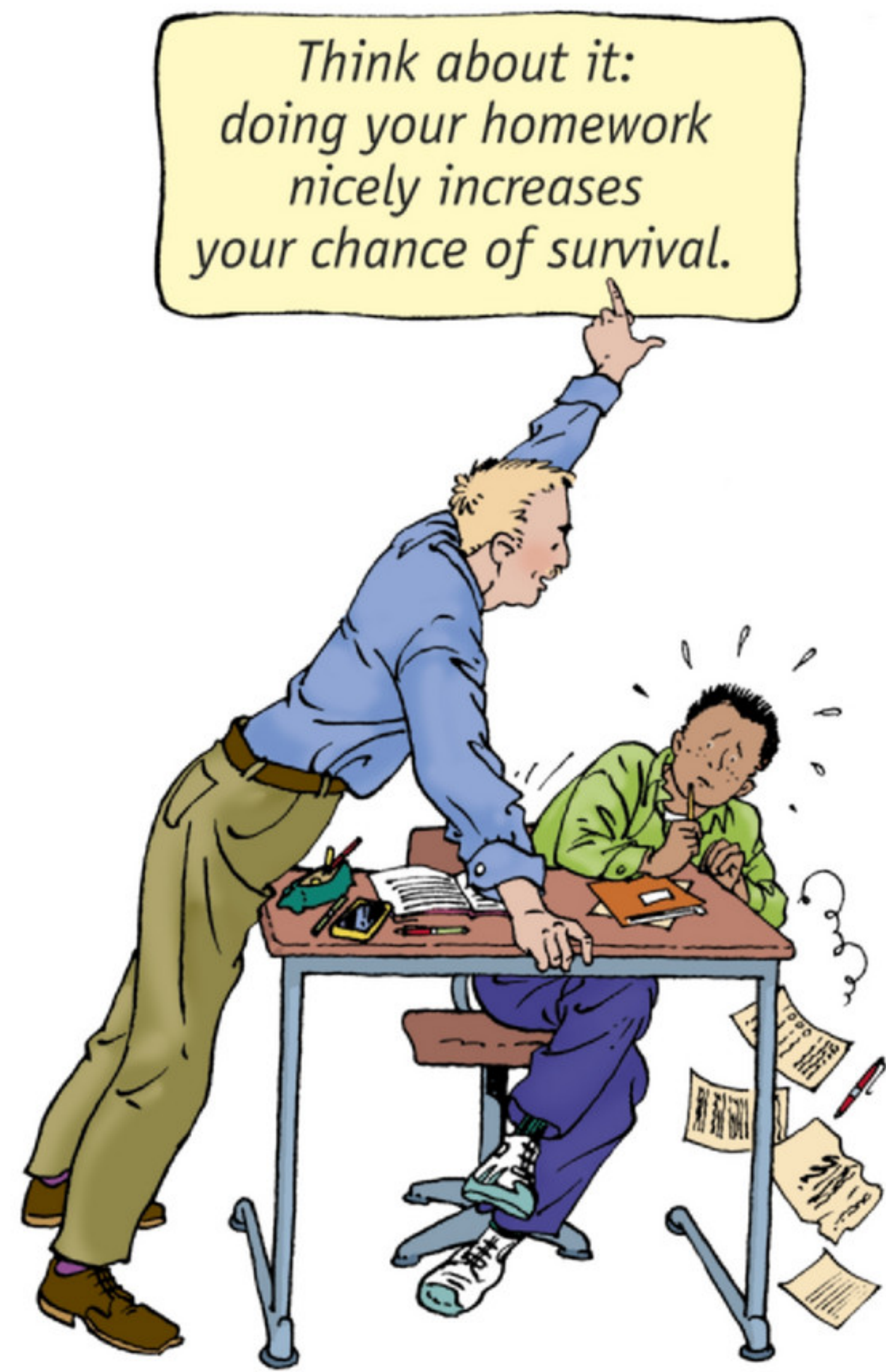
HOW IS BEHAVIOUR DETERMINED?

Much of the behaviour of animals and humans is **learned**. A heron learns where frogs can be found and a toddler learns to use a spoon when eating. Biologists have shown that behaviour can also be determined by **hereditary factors** (see figure 35).

▼ Fig. 35

INVESTIGATION	PECKING BEHAVIOUR IN CHICKS: HEREDITARY OR LEARNED?
Problem definition	When chicks peck for food, is this hereditary behaviour or learned behaviour?
Hypothesis	Pecking behaviour is learned behaviour.
Experiment	Caps are placed over the heads of new-born chicks so that they cannot see anything. After that, the chicks are released in a room with no other chickens and with chicken feed on the floor. The caps are then removed from their heads.
Results	 The chicks start pecking at the chicken feed immediately.
Conclusion	

▼ Fig. 36



THE FUNCTION OF BEHAVIOUR

Animals and humans can respond to stimuli and therefore behave in all kinds of ways. They can look for food and they can avoid harmful stimuli (self-regulation). Animals can reproduce. They can determine who is the boss among members of their species (interaction). The behaviour of animals and humans has continuously adapted to the changing environment over the course of time as a result of evolution. For instance, humans changed from hunter-gatherers into farmers and livestock holders. Nowadays, many people specialise in professions that provide certain services, such as car mechanics or surgeons. Behaviour that offers the best **chance of survival** will always continue to exist. Today, working in professions that provide services ensures the best chance of survival for many people. Much of the behaviour of humans and animals is ultimately about increasing their chance of survival (see figure 36).

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INFLUENCING BEHAVIOUR

There are a lot of substances that affect how the senses and the nervous system work and so affect your behaviour. Examples are **alcohol**, some **medicines** and **drugs**. Alcohol is the most widely used of the three. This part of the basics covers some effects of alcohol. You will learn more about the effects of alcohol in the second year.

ALCOHOL

Everyone has their own reasons to drink or not drink alcohol. The following reasons are often mentioned: wanting to belong, curiosity, boredom, relaxation and sociability. Acting tough can also be a reason to drink. Some people drink to forget their problems.

Reasons for not drinking include the fact that it is bad for your health or a waste of money. Some people have had bad experiences with alcohol. And there are people who simply do not need alcohol or are not interested in it. Drinking alcohol is forbidden in Islam. Alcoholic drinks are generally grouped into three categories: beer, wine and spirits. In addition, a lot of alcoholic mixers have become available in recent years (see figure 37).

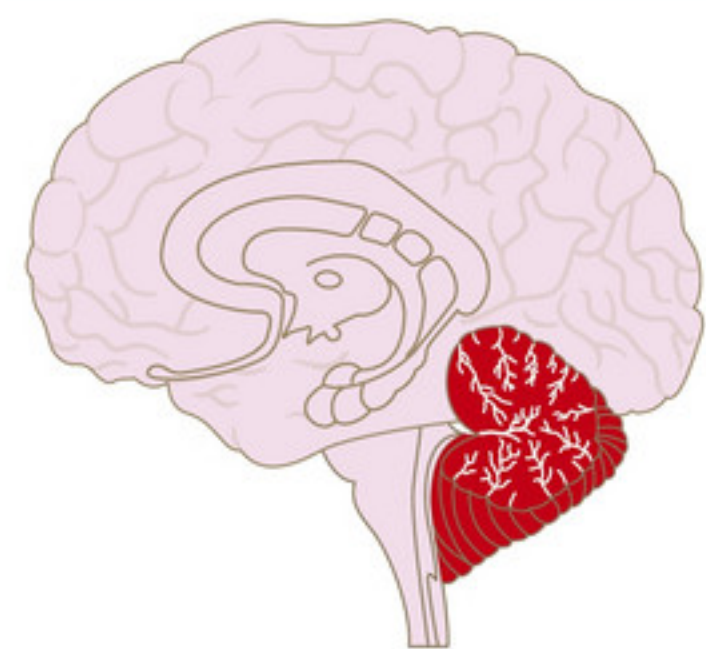
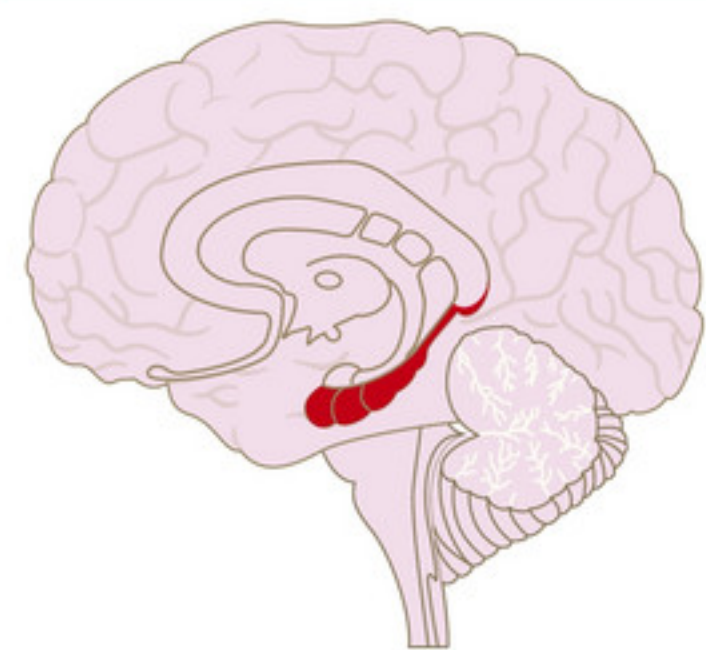
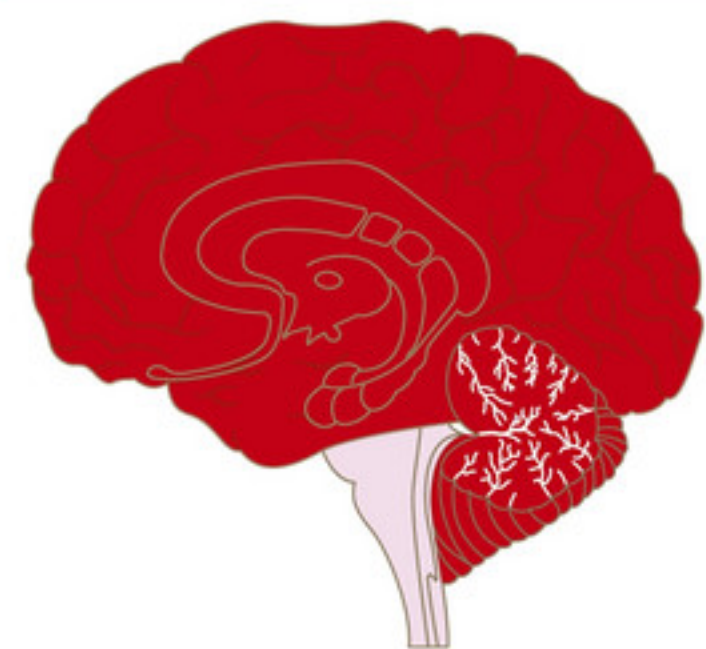
► Fig. 37 Alcoholic drinks.



Alcohol is a chemical with a **narcotic effect**. It has all kinds of effects on your mood and behaviour. Inhibitions disappear, your memory and concentration are reduced and your self-criticism disappears. The more you drink, the more severe the effects are.

If an adult drinks a few alcoholic drinks now and then, they may get pleasure from it. But drinking alcohol also has harmful effects. When young people drink alcohol, the harmful effects are much worse than for adults. Your brain keeps developing until the age of 24. Alcohol disrupts this development (see figure 38). The harmful effects of alcohol are permanent (see figure 39).

▼ Fig. 38 Harmful effects of alcohol on various parts of the brain.

Part of the brain	Involved in	Development largely complete	Effect of alcohol
 Cerebellum	movement, balance	about age 12 to 14	damaged, reduction in volume
 Hippocampus	learning and memory	about age 16	volume 10 to 35% less in people who drink a lot, poor memory
 Front part of the cerebrum	thinking, planning, organising, decision-making, evaluation, controlling impulses, mood	about age 24	volume reduction, poor scores in intelligence tests
 Nerve fibres throughout the brain	all brain functions, communication between brain cells	about age 24	fewer connections between brain cells

Taken from a fact sheet on alcohol and the adolescent brain produced by the Dutch Institute for Alcohol Policy.

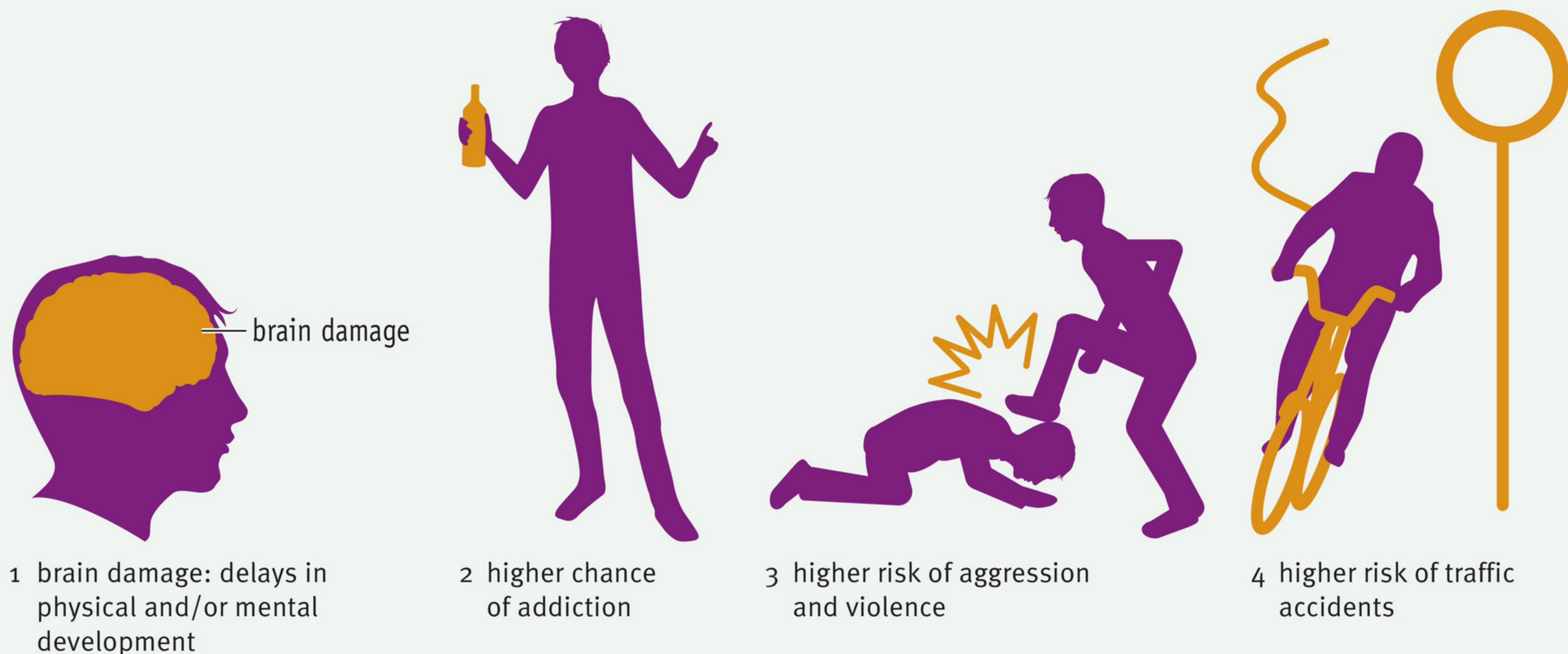
▼ Fig. 39

Harmful effects of alcohol on young people

In recent years, more and more research has shown that drinking alcohol at a young age is particularly harmful. This is because your brain keeps developing until you are about 24. Alcohol disrupts this development. Certain parts of the brain become smaller and many nerve fibres are damaged. A lot of connections are made between the nerve cells in the brain until you are well in your twenties. Brain scans show that the brain connections of teenagers who have drunk a lot are weakened; they have been affected by alcohol. This damage can never be repaired. If these connections do not grow properly in your youth, it will have permanent consequences throughout the rest of your life, such as memory disorders, learning disorders, depression, reduction of intelligence or emotional problems.

If anything is missing in the brain, it cannot be restored later on.

And more problems are lying in wait. Young people who start drinking alcohol at an early age run a much greater risk of getting addicted to alcohol. They have then become dependent on alcohol. Furthermore, young people often go to discos, bars and events. There is then a relatively high chance of getting involved in aggression and violence. Finally, when young people use alcohol they have a greater risk of becoming involved in a traffic accident than older road users. So this is not a pleasant prospect for young people who start drinking alcohol at an early age. And this is certainly true if they drink alcohol often, or a lot of alcohol at a time.



The narcotic effect of alcohol on the brain reduces your sensory perception and reaction time. Each year, about two hundred people die and three thousand get severely injured on the roads in the Netherlands as a result of alcohol. The percentage of young people among alcohol-related traffic victims is high. In recent years, people have become more and more worried about the drinking behaviour of young people. Some young people start drinking alcohol at an early age, but it is getting clearer and clearer that drinking alcohol at a young age is very harmful. In 2014, the age limit for buying alcohol was increased from 16 to 18.

8 The endocrine system

This basics section tells you what hormones are and how they work. Figure 40 is about Brian. One of his hormones does not work properly.

▼ Fig. 40 Brian.

Diabetes

When Brian was eighteen months old, he suddenly got diabetes. Diabetes occurs when the hormone insulin does not work properly. As a result, the amount of glucose (a sugar) in the blood is not properly regulated. Because of his diabetes, Brian has to watch what he drinks and eats. That certainly is not nice, but Brian does not see his diabetes as a handicap at all. Brian, who is thirteen, has to inject himself with the hormone insulin twice a day. Figures 40.1 to 40.3 show you how this is done. In the long run, diabetes often causes damage to the body. “But someone with diabetes isn’t an outsider,” says his mother. “If you stick to the rules, you can limit a lot of the damage and often lead a full life just like anyone else.” Brian is a fanatic tennis player and basically does the same things as other boys of his age.

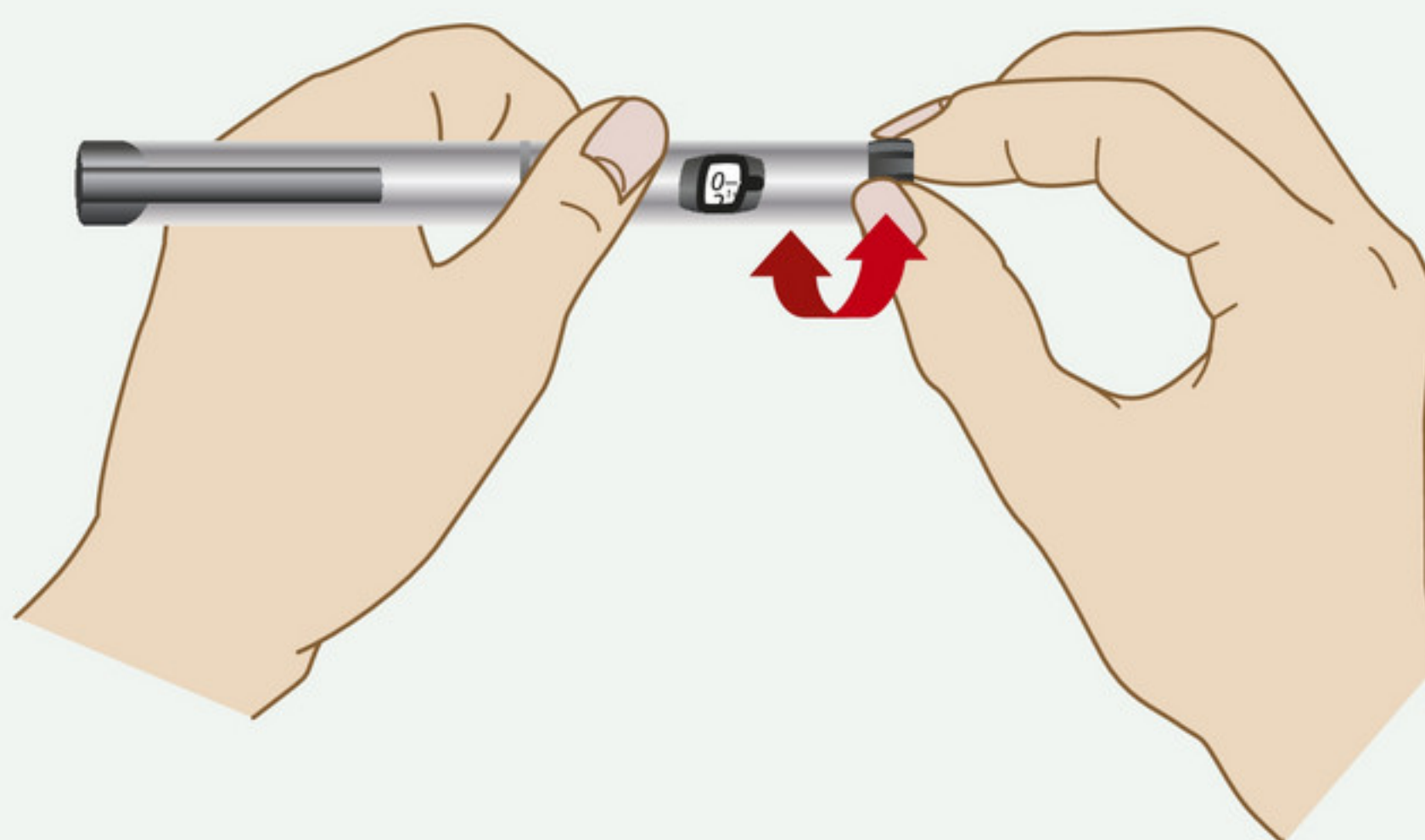
There are various types of diabetes. Diabetes types 1 and 2 occur most often. Brian has type 1 diabetes. What is wrong with his body is that it no longer produces insulin at all. The bodies of people with type 2 diabetes produce too little insulin. Being overweight and a lack of exercise increase the risk of type 2 diabetes. Elderly people in particular are likely to get type 2 diabetes.



The number of people with type 2 diabetes is increasing substantially. More and more young people are getting type 2 diabetes too now. Being overweight and a lack of exercise in particular are making the number of people with type 2 diabetes increase. And that is bad news for young people. Diabetes is usually incurable and young people with diabetes will have diabetes for most of their lives. The longer someone suffers from diabetes, the more severe the consequences of the disorder, such as eye problems, kidney failure and cardiovascular diseases.



1 measuring glucose levels in the blood (sometimes)

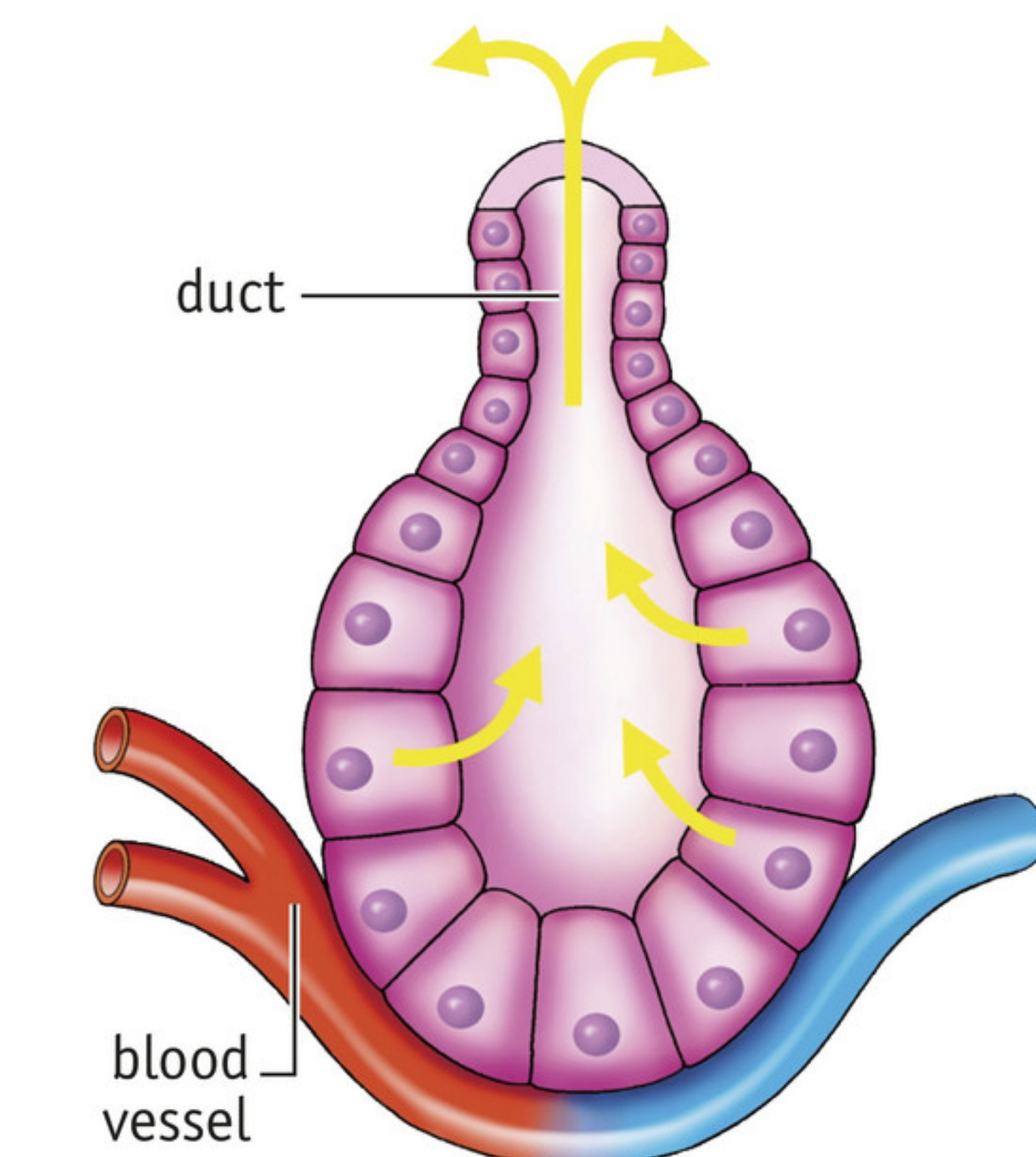


2 adjusting the dose of insulin

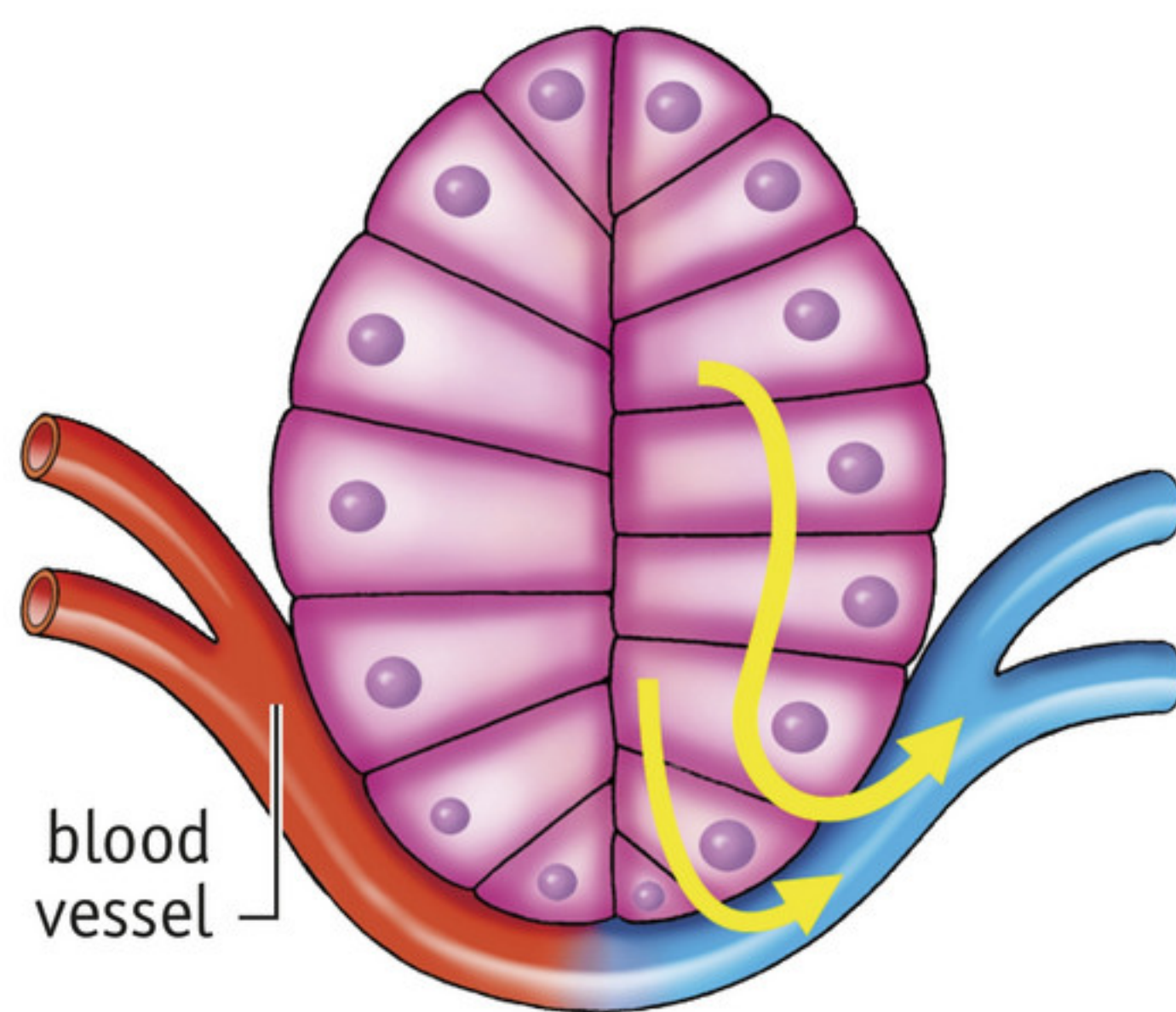


3 injecting insulin

▼ Fig. 41 Glands.



1 gland with duct



2 endocrine gland

HORMONES

When controlling processes in your body, the nervous system often works together with the endocrine system. The endocrine system consists of a number of **endocrine glands**. A gland is an organ that produces certain substances. Endocrine glands produce **hormones**. Hormones are substances that control the functioning of certain organs.

The substances produced by many glands are discharged via ducts (see figure 41.1). Examples of such glands are salivary glands, sweat glands and tear glands.

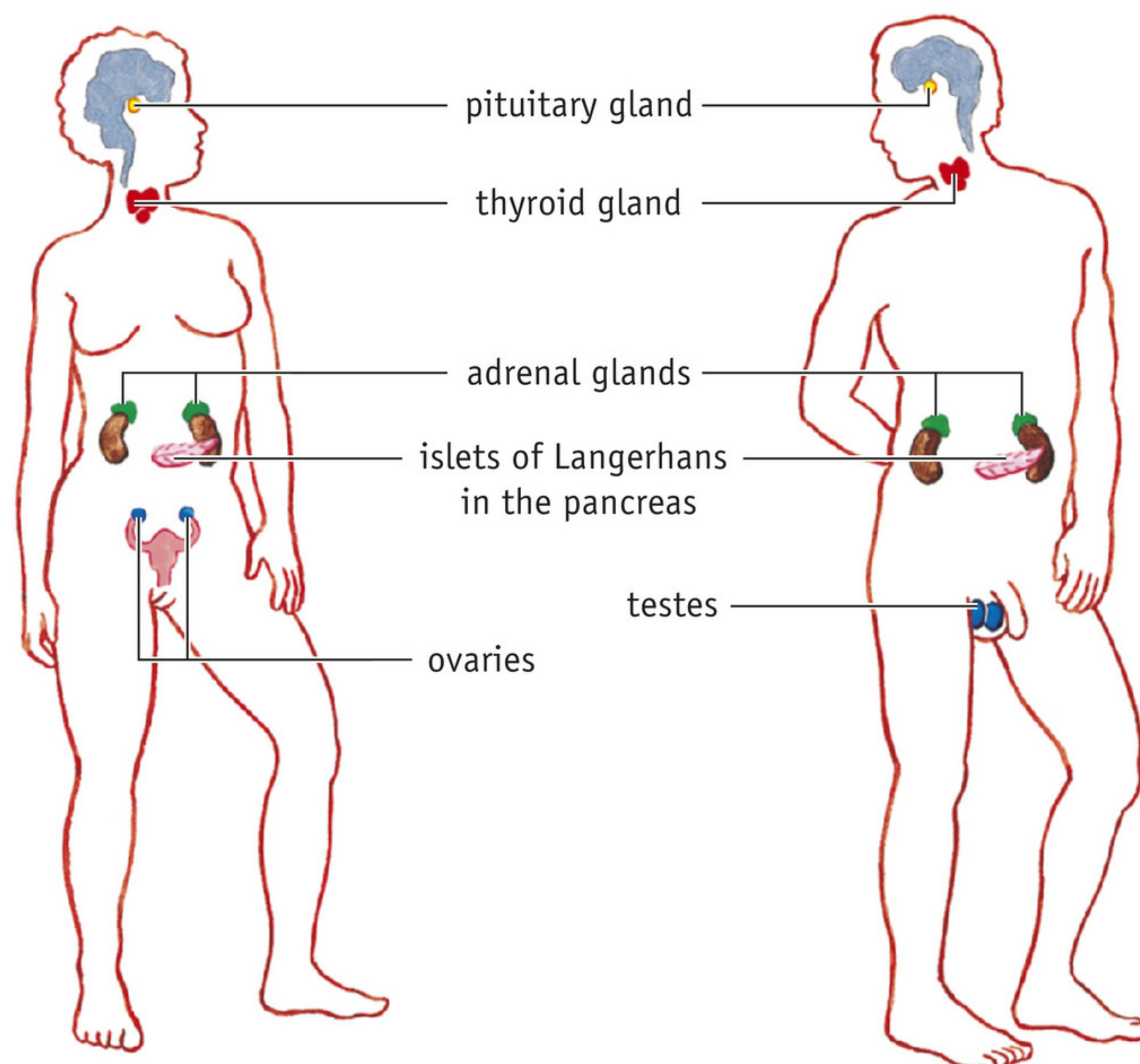
Endocrine glands secrete their hormones into the blood that flows through the gland. Many endocrine glands therefore have no ducts (see figure 41.2). The hormones end up throughout the body via the blood. However, hormones only have an effect in those tissues and organs that are sensitive to them.

The endocrine system mostly controls slow, long-term processes. Hormones also affect metabolism, reproduction, growth and development.

Important endocrine glands are the pituitary, the thyroid, the islets of Langerhans in the pancreas, the adrenal glands, the ovaries and the testes. The locations of these endocrine glands are shown in figure 42.

WB EXERCISES 32 TO 34, PAGE 67

▼ Fig. 42 Location of the major endocrine glands.



REGULATING THE BLOOD GLUCOSE LEVEL

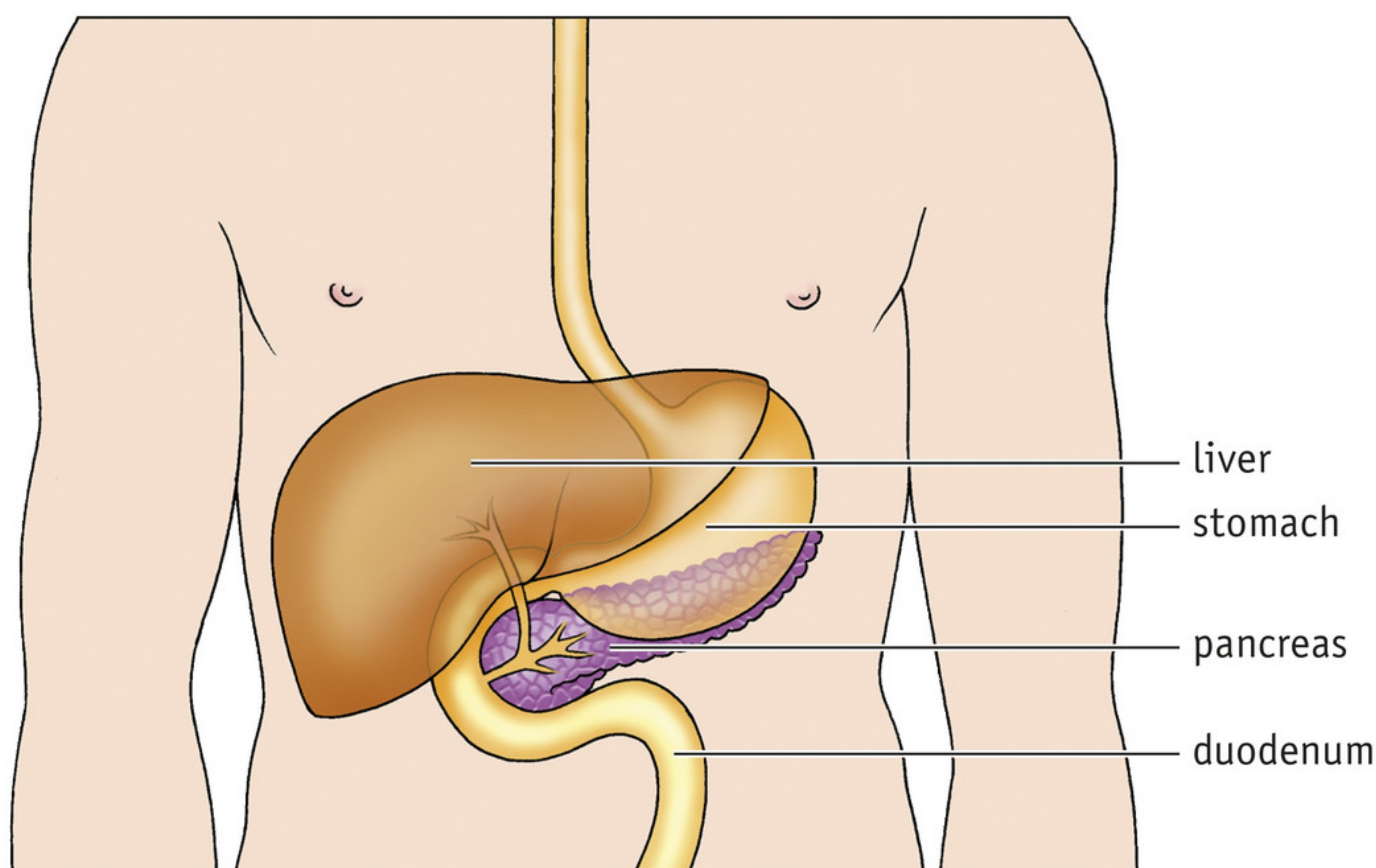
You learned in Unit 2 (Plants) that **glucose** is a sugar produced by plants in photosynthesis. Our food that comes from plants also contains glucose. Glucose is a fuel for the cells in your body. When you digest food, glucose is taken up in the blood through the wall of the small intestine. After a meal a lot of glucose may end up in the blood. Certain hormones from the pancreas regulate the amount of glucose in the blood.

The **islets of Langerhans** are groups of cells located between the other cells of the pancreas (see figure 43). The pancreas is a digestive gland. The islets of Langerhans produce the hormones **insulin** and **glucagon**. These hormones control the blood **glucose level**.

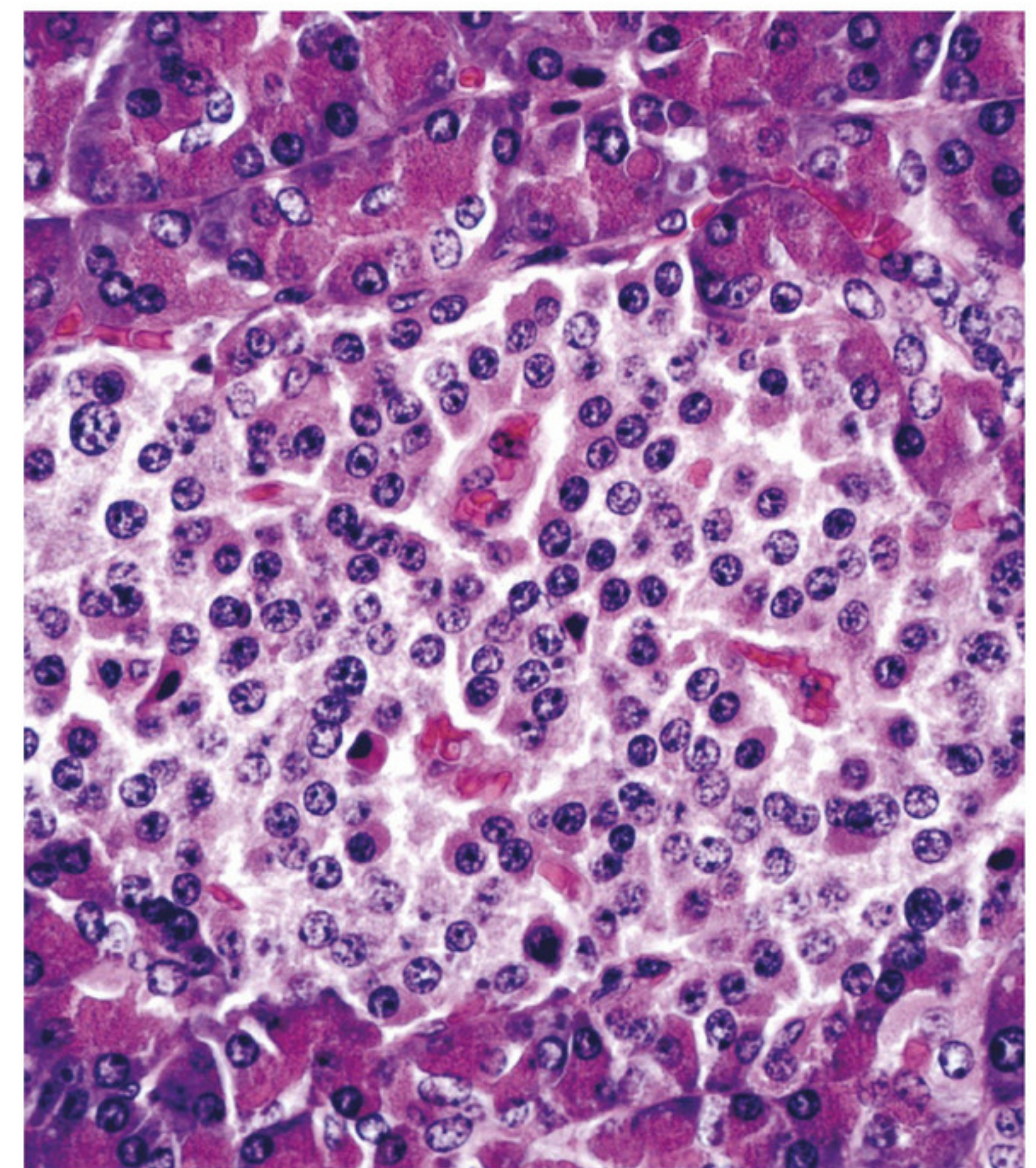
Blood contains 0.1% glucose on average. The blood glucose level is also known as the **blood sugar level**. Insulin and glucagon make sure that the blood sugar level is kept more or less constant.

After a meal the glucose level may be higher than 0.1%. The islets of Langerhans then respond by producing a lot of insulin. Insulin makes the liver and muscles convert glucose into **glycogen**. Glycogen is a fuel reserve that is stored in the liver and muscles. The blood glucose level decreases as a result of glucose being converted into glycogen.

▼ Fig. 43 Islets of Langerhans.



1 location of the pancreas



2 an islet of Langerhans
(microscope photo)

In figure 40, you read that Brian has to inject himself with the hormone insulin twice a day because of his diabetes. In people with **diabetes**, the islets of Langerhans produce too little insulin. Less glucose is therefore converted into glycogen, which means that the glucose level rises. The blood glucose level can rise to a maximum of 0.16%. If the blood glucose level goes above 0.16%, glucose is excreted in the urine. People then say there is sugar in the urine.

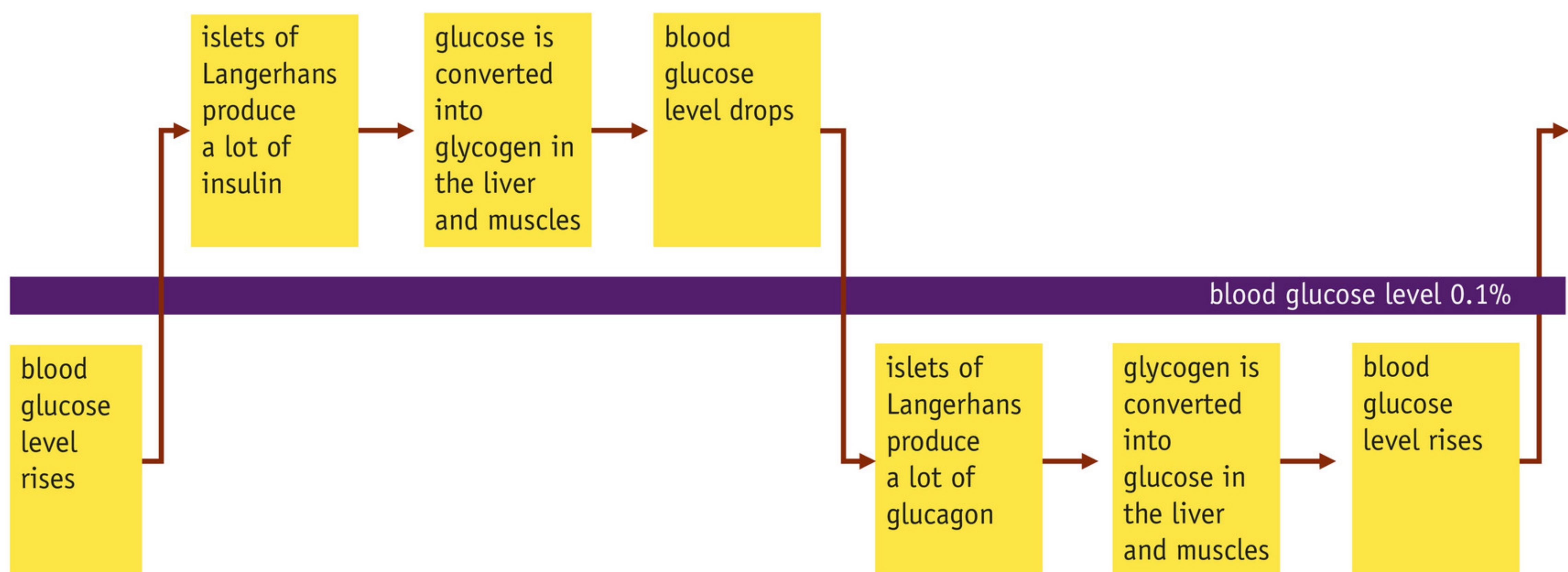
Someone who has diabetes that has not been detected yet will be very tired and thirsty. A blood test can be used to determine if someone has diabetes. To top up the insulin deficiency, additional insulin can be given to diabetics. Diabetics are often taught to inject themselves with insulin. The amount of insulin injected must be matched up to the amount of food eaten by the patient.

Glucose is the most commonly used fuel in cells. A lot of glucose is used up in cells during physical exercise. The cells then take up glucose from the blood. When the blood glucose level gets below 0.1%, the islets of Langerhans produce a lot of glucagon. Glucagon makes the liver and muscles convert glycogen into glucose. The glucose is taken up in the blood. As a result, the blood glucose level rises.

Figure 44 is a diagram showing how the blood glucose level is controlled.

WB EXERCISES 35 TO 37, PAGE 68

▼ **Fig. 44** Regulation of the blood glucose level.

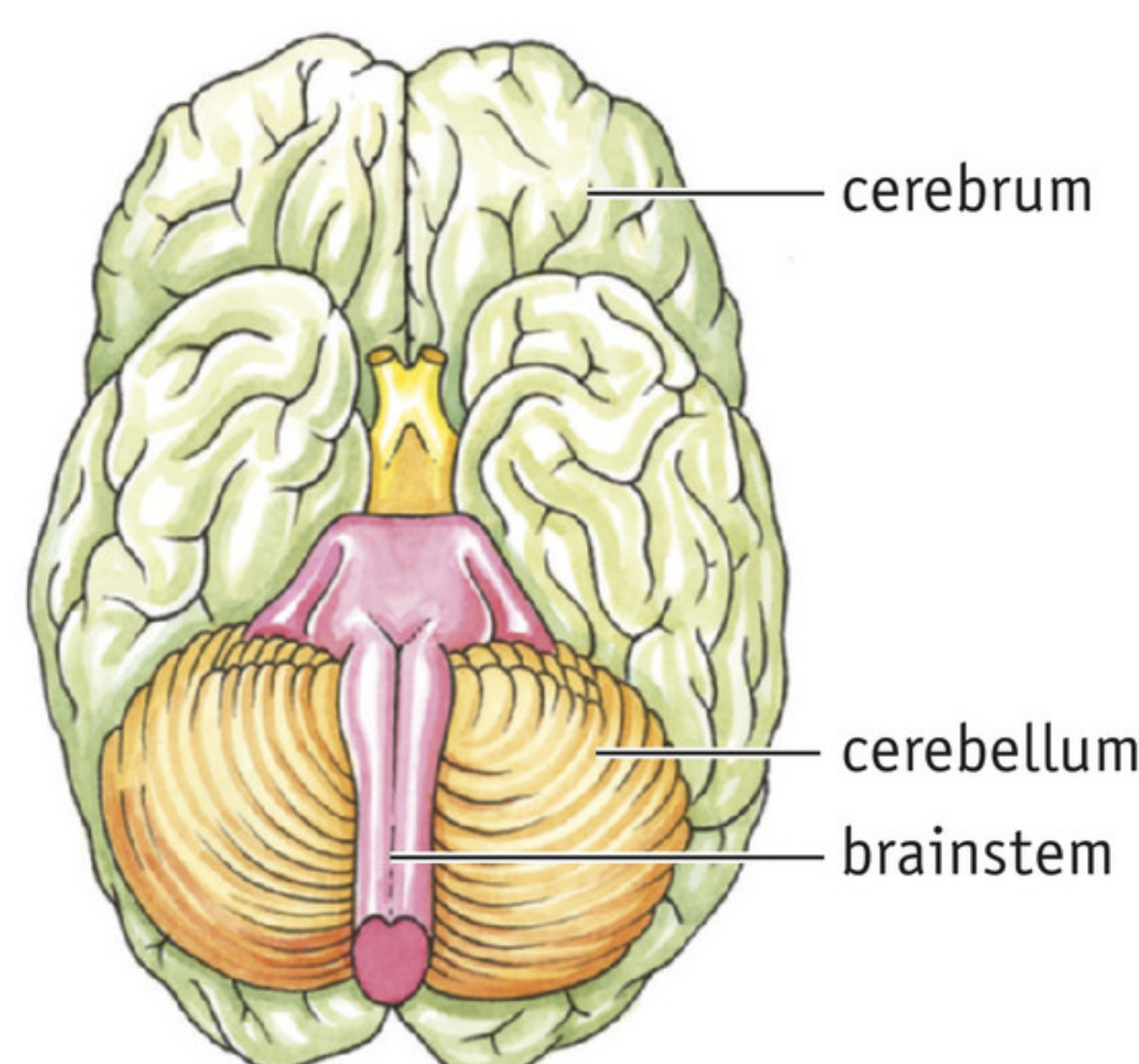


9 The brain

The **brain** consists of the brainstem, the cerebrum and the cerebellum (see figure 45).

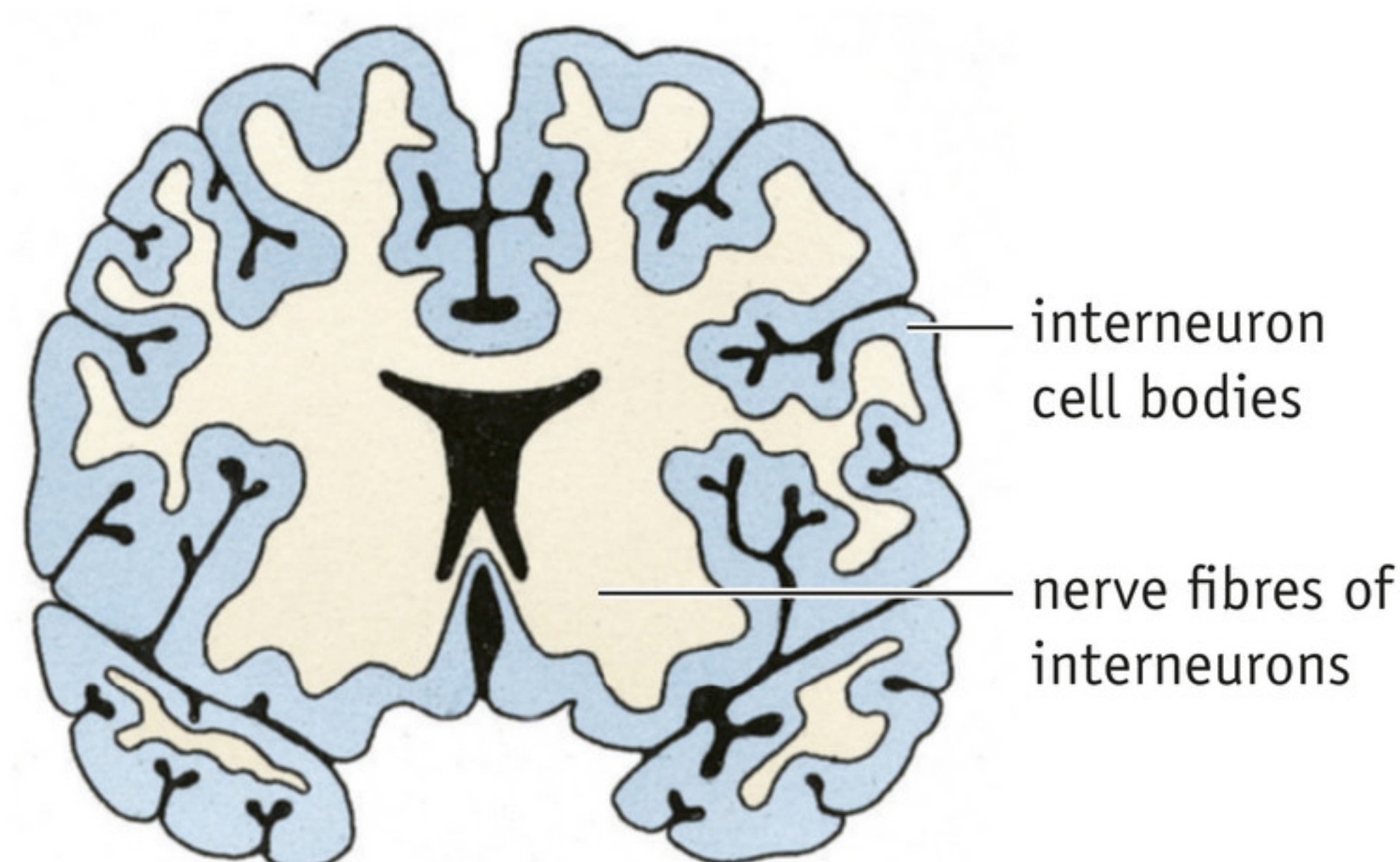
The **brainstem** is an extension of the spinal cord. The brainstem passes impulses from the spinal cord to the cerebrum and the cerebellum and vice versa. Parts of the head and the neck are connected to the brainstem by nerves. Impulses from the sense organs in the head and neck enter the brainstem via these nerves. The brainstem passes these impulses to the cerebrum and the cerebellum. The brain also passes impulses from the cerebrum and the cerebellum to nerves that run to the muscles and glands in the head and the neck.

► **Fig. 45** The brain (viewed from below).



The cerebrum and the cerebellum each consist of two halves: a left half and a right half. The cerebrum in particular has lots of folds (see figure 46). The **cortex** (the outer part) of the cerebrum and cerebellum contains lots of cell bodies of interneurons. The cerebral cortex is grey in colour and so it is also called the 'grey matter'. The **medulla** (the inner part) contains a lot of nerve fibres of interneurons. The medulla of the cerebrum and the cerebellum is lighter in colour than the cortex and is also known as the 'white matter'. This paler colour is caused by the insulating layers around the nerve fibres.

► **Fig. 46** The cerebrum (cross section).

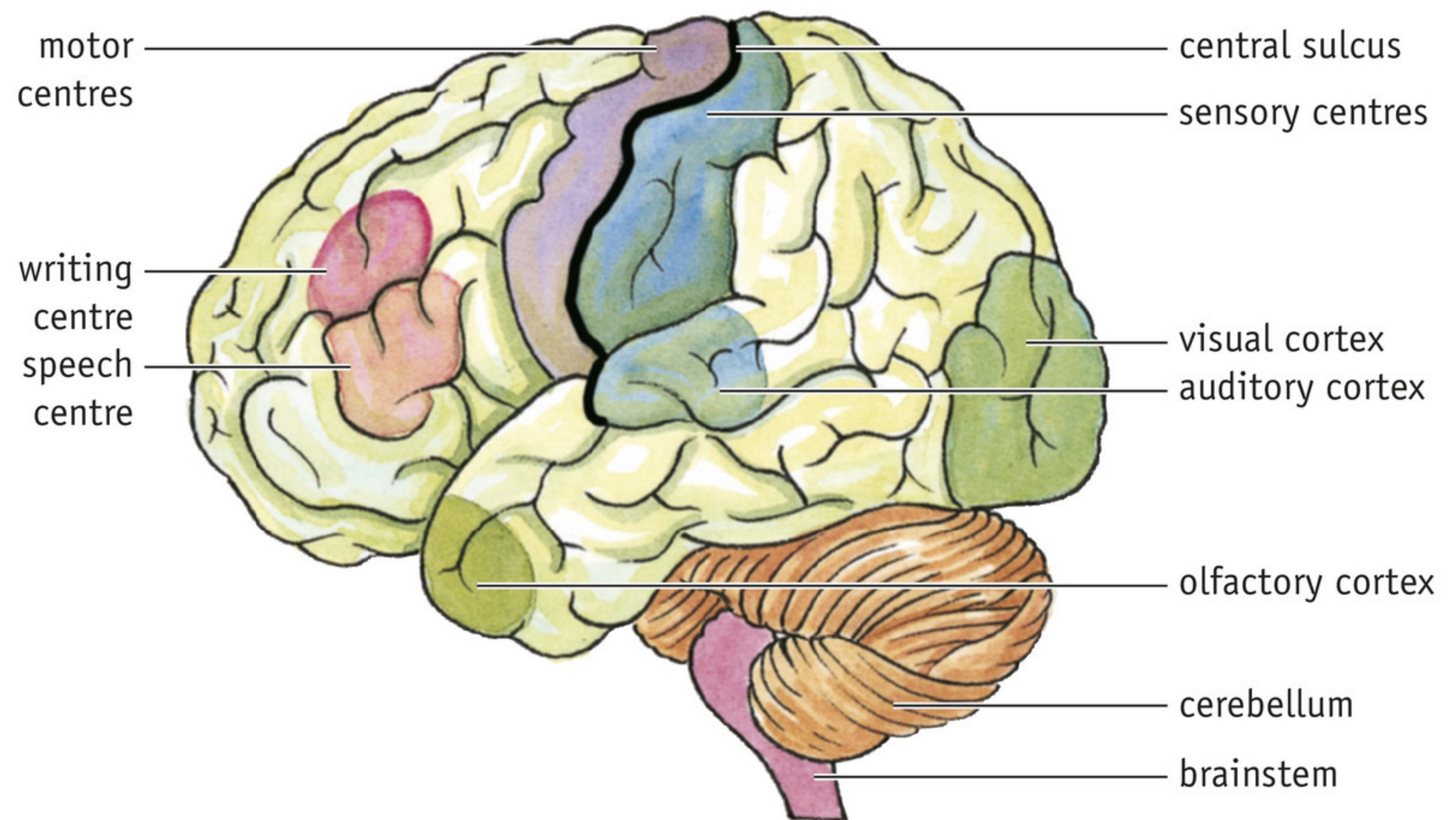


BRAIN CENTRES

A great many impulses are passed to the **cerebrum** by the senses. You are only aware of a stimulus after these impulses have been processed in the cortex of the cerebrum. The *location* where the impulses arrive at the cerebrum and where they are processed determines what you perceive. The cerebrum contains clusters of cell bodies of interneurons: the **brain centres** (see figure 47). A dramatic accident was one of the first indications of the existence of brain centres (see figure 48).

We distinguish between sensory centres and motor centres. There is a sensory centre and a motor centre in each half of the brain for every part of the body.

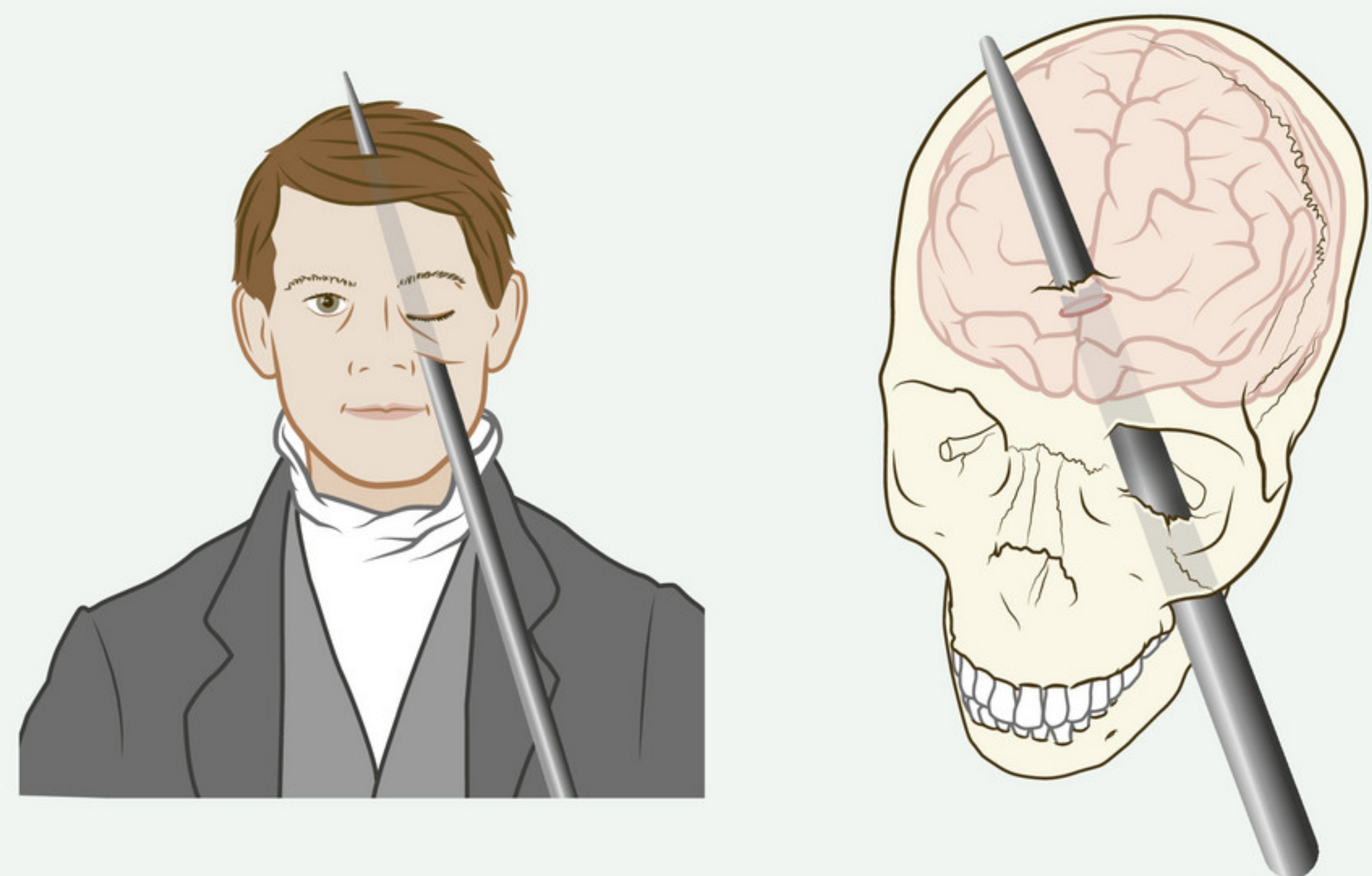
► **Fig. 47** The brain and the location of the brain centres.



▼ **Fig. 48**

A dramatic accident

In 1848, Phineas Gage's head was pierced by an iron bar as a result of a dynamite explosion. Phineas survived the accident, despite substantial destruction in the front part of his brain. He lost an eye, but apart from that only his personality was changed much after the accident. He changed from a quiet, hard-working man into an anti-social misfit. This incident was one of the first indications that certain parts of the brain have specific functions.



SENSORY CENTRES AND MOTOR CENTRES

Most of the **sensory centres** can be found in the cerebral cortex behind a large groove called the **central sulcus** (see figure 47). The sensory centres for vision, hearing and smell are located separately in the cerebral cortex. Incoming impulses are processed in the sensory centres. The visual cortex, for example, receive impulses that come from your eyes. You can then see things because these impulses are processed. If there is a failure in the visual cortex, you can become blind even though your eyes continue to function properly. **Conscious sensation** (awareness) of stimuli takes place because incoming impulses are processed in the sensory centres of the cerebrum. Most of the **motor centres** can be found in the cerebral cortex in front of the central sulcus. The motor centres for writing and speech are located separately in the cerebral cortex. Impulses can be created in the motor centres. These impulses can be passed to the muscles via the brainstem, the spinal cord and the motor neurons. These impulses result in deliberate movements. We call these **conscious movements** or **voluntary movements**.

CEREBELLUM

Many of our movements involve coordinating various motions at the same time. The **cerebellum** is responsible for the coordinating the movements. The cerebellum is responsible for the **coordination** of all movements of your body. If you stretch out your arms to catch a ball while running, your eyes perceive the motion of the ball. In the cerebellum, these perceptions are combined with your own motion. This lets you catch the ball while you are running. The cerebellum also makes it possible for you to keep your balance (see figure 49).

WB EXERCISE 38, PAGE 71

▼ Fig. 49 The cerebellum coordinates movement.



1 when catching a ball



2 when keeping your balance

10 Paths taken by nerve impulses

When responding to stimuli, impulses can travel through the nervous system in various ways. There is a difference between **voluntary responses** and **reflexes**.

VOLUNTARY RESPONSES

Somebody pushes you aside. You feel the push, look round and push back. In this case, you are aware of the push before you react. Pushing back is a **voluntary response** (see figure 50). At the moment when you are pushed, impulses from sensory cells in your skin go to interneurons in your spinal cord via sensory nerves. The interneurons in the spinal cord pass the impulses to interneurons in the brainstem via their nerve fibres. They conduct the impulses to interneurons in the cerebrum. The impulses arrive in sensory centres and are processed there. This is when you become aware of the push.

▼ Fig. 50 A voluntary response.



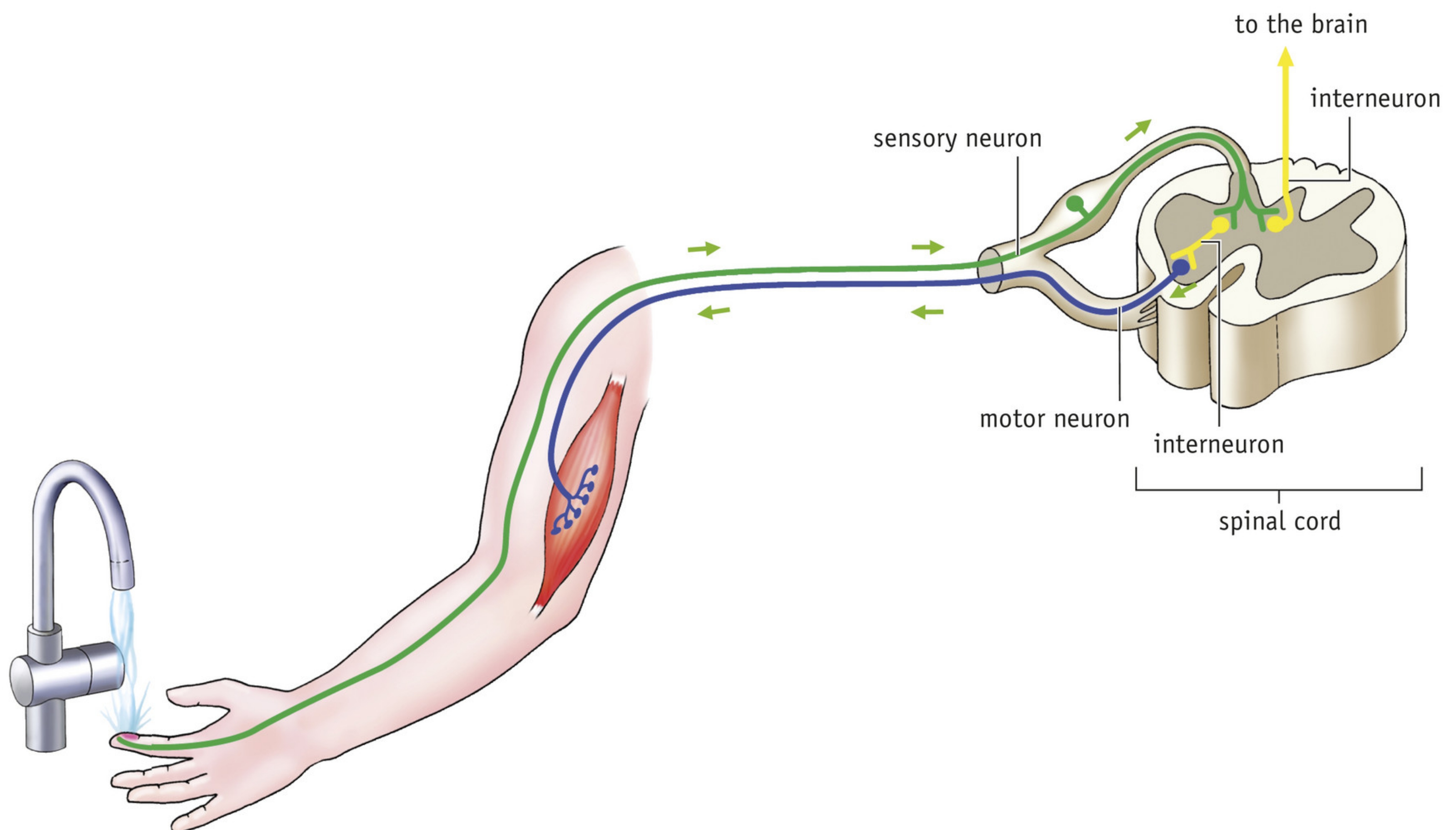
At that moment you can choose between looking round and pushing back, or doing nothing. You choose to look round and push back. At that moment, impulses are created in motor centres of your cerebrum. These impulses are transmitted to interneurons in the cerebellum, the brainstem and the spinal cord via nerve fibres. From the brainstem, impulses are passed to the muscles in your neck via motor neurons. You turn your head and look around. Impulses are passed from the brainstem to the muscles in your torso and limbs via motor neurons: you push back. Your cerebellum coordinates the movements to make sure you do not lose your balance.

REFLEXES

In exercise 39 you saw that your lower leg responded to a tap on the patellar tendon. The response of your lower leg to the tap is an example of a **reflex**. A reflex is a **fixed, rapid and involuntary response** to a certain stimulus. Other examples of reflexes are the withdrawal reflex, the blink reflex and the pupillary light reflex.

The diagram in figure 51 shows an example of a **withdrawal reflex**. You are going to wash your hands. The water turns out to be very hot. When you touch the hot water, you immediately withdraw your hand. You will only register the pain afterwards.

▼ Fig. 51 Withdrawal reflex.



The hot water on your hand creates impulses in certain sensory cells in your skin. These impulses are passed to interneurons in your spinal cord via sensory neurons. The interneurons immediately pass the impulses to motor neurons. The motor neurons pass the impulses to muscle cells in your arm muscles. As a result, your arm muscles contract, which lets you pull your arm away.

Interneurons also pass impulses via your spinal cord to your brain (see figure 51). However, the path from the spinal cord to the cerebrum via the brainstem is longer than the path from the spinal cord to the arm muscles. As a result, you pull your hand away first and only feel the pain afterwards. The speed of reflexes is often needed to protect your body against injuries. You will find more examples of reflexes in figure 52.

The path that impulses take in a reflex is called a **reflex arc**. The reflex arcs of the head and the neck go via the brainstem. The reflex arcs of the torso and the limbs go via the spinal cord. The cerebrum is not involved in reflex arcs. Even so, the impulses that trigger many reflexes do also reach the cerebrum. You felt the tap during the practical about the patellar reflex.

WB EXERCISES 40 AND 41, PAGE 73

▼ Fig. 52

Reflexes

When you are eating or drinking, the swallowing reflex makes sure that the food ends up in your gullet and not in your windpipe or lungs. If anything does go wrong and a little of what you are eating or drinking ends up in the respiratory tract, the cough reflex is triggered. The powerful exhalation in a cough clears your respiratory

tract. The sneeze reflex works in the same way. If irritant substances get into your nose, a powerful sneezing exhalation tries to clear the nose. If you smell something very unpleasant, this may cause a gag reflex. A vomiting reflex may be triggered in your stomach as a result of toxins in the food or too much alcohol.

Summary

OBJECTIVE 1

You must be able to describe how sense organs work. You must also be able to name the sense organs with their location and their adequate stimuli.

- Sense organ: an organ that is sensitive to stimuli.
 - Stimulus: information from the surroundings that has an effect on an organism.
- When sensory cells receive stimuli, they generate impulses.
 - Impulses are electrical signals that are transmitted from the senses to the brain via nerves.
 - The brain processes the impulses that come from the senses.
 - Threshold value: the lowest intensity of stimulus that causes an impulse.
- Adequate stimulus: the type of stimulus that a sensory cell is particularly sensitive to.
 - The sensory cell has a low threshold value for this stimulus.
- The threshold value is not always the same.
 - Habituation: if a stimulus persists, the sensory cells start producing fewer impulses.
 - Motivation affects the threshold value.

	Location	Adequate stimulus
Sense of sight	in the eyes	light
Sense of hearing	in the ears	noise
Sense of balance	in the ears	gravity
Sense of smell	in the nose	odour
Taste receptors	in the tongue	taste
Heat receptors	in the skin	heat
Cold receptors	in the skin	cold
Pressure receptors	in the skin	pressure
Touch receptors	in the skin	gentle contact

OBJECTIVE 2

You must be able to name the parts of the skin and the subcutaneous tissue with their functions and characteristics.

- Epidermis: corneal layer and basal layer.
 - Corneal layer (remains of dead, cornified cells): protection against damage, dehydration and pathogens (bacteria).

- Basal layer (living cells): the bottom layer of cells divides continuously. This adds new layers to the corneal layer as it continually wears away.
- Calluses: a very thick corneal layer.
- Hair with follicle (protrusion of the basal layer) and sebaceous glands.
 - Sebum keeps the hair and the corneal layer flexible.
- Dermis with sensory receptors, nerves, pain receptors, hair muscles, blood vessels and sweat glands.
 - Sense receptors: heat, cold, pressure and touch receptors. Touch receptors are found just below the epidermis. The pressure receptors are found deeper in the skin.
 - Pain receptors (the ends of certain nerves): register pain. Pain receptors are everywhere in the body.
 - Sweat glands: produce sweat. Evaporation of sweat cools the body down.
- Subcutaneous tissue:
 - stores fat. The fat is used as an energy reserve and has an insulating effect.

OBJECTIVE 3

You must be able to describe the process of tasting various flavours.

- The sides of the grooves in the tongue have taste buds.
 - The taste buds contain sensory cells.
 - There are separate taste buds for sweet, sour, salty and bitter.
 - Tasting all other flavours is a result of the sense of smell registering smells.

OBJECTIVE 4

You must be able to name the parts of the ear with their functions and characteristics.

- Auricle (outer ear): collects sounds.
 - Sounds are vibrations in the air.
 - High-pitched sounds make the air vibrate fast; low-pitched sounds make the air vibrate slowly.
 - Loud noises are when the vibrations move the air a lot; quiet sounds are for small air movements.
- Ear canal: conducts sounds to the eardrum.
 - Earwax glands: produce earwax, which keeps the eardrum flexible.
- Eardrum: made to vibrate by sounds.
- Middle ear: cavity behind the eardrum filled with air.
 - Ossicles (hammer, anvil, stirrup): tiny bones that pass on the vibrations of the eardrum to a membrane (oval window) in the cochlea.

- Cochlea: contains a fluid and sensory cells.
 - The vibrations in the fluid make the sensory cells give off impulses.
- Auditory nerve: passes impulses to the brain.
- Eustachian tube: connects the middle ear to the back of the throat.
 - The Eustachian tube opens when you swallow or yawn. This lets the air pressure on both sides of the eardrum stay the same.

OBJECTIVE 5

You must be able to name the different parts in and around the eye with their functions and characteristics.

- Organs around an eye:
 - Eyebrows: make sure that sweat (moisture) runs past the eyes and not into them.
 - Eyelashes protect the eyes against dirt and bright light.
 - Tear glands: produce tears. Tears protect the eyes against dehydration and rinse away small particles of dust and irritants.
 - Eyelids: spread tears across the eyes and protect the eyes against flies etc.
 - Tear ducts: excess tears drain to the nasal cavity through the tear ducts.
- Parts of the eye:
 - Eye muscles: turn the eye in the desired direction.
 - Sclera (white): tough, provides protection.
 - Cornea (transparent): at the front of the eye, the sclera gives way to the cornea.
 - Choroid: contains a lot of blood vessels: the choroid provides nutrients to most of the eye.
 - Iris: at the front of the eye, the choroid becomes the iris.
 - Pupil: opening in the iris.
 - Lens: behind the iris and the pupil. The lens makes sure that you can see sharply.
 - Retina: contains sensory cells. Light produces impulses in the sensory cells.
 - Fovea: area at the centre of the retina. The sensory cells in the fovea let you see most sharply.
 - Optic nerve: passes impulses to the brain.
 - Blind spot: the part of the retina where the optic nerve leaves the eye. The blind spot does not contain sensory cells.
 - Vitreous body: jelly-like substance that keeps the retina in place.

OBJECTIVE 6

You must be able to describe how the pupillary light reflex regulates the size of the pupil.

- Function of the pupillary light reflex: regulates the amount of light falling onto the retina.
 - The sensory cells in the retina are protected against light that is too bright by the pupillary light reflex.
- The iris has circular muscles and radial muscles.
 - When bright light falls on the retina, the circular muscles contract and the radial muscles relax. This makes the pupil smaller.
 - When not much light falls on the retina, the circular muscles relax and the radial muscles contract. This makes the pupil larger.

OBJECTIVE 7

You must be able to name the functions of the nervous system.

- Parts of the nervous system:
 - the central nervous system: brain and spinal cord;
 - nerves.
- Nerves connect all parts of the body to the central nervous system.
 - Parts of the head and neck are connected by nerves directly to the brain.
 - The torso and limbs are connected by nerves to the spinal cord.
- Functions of the nervous system:
 - processing impulses from the senses;
 - controlling the functions of the muscles and glands.

OBJECTIVE 8

You must be able to describe the structure of a nerve cell and a nerve.

- Structure of a nerve cell:
 - cell body with nucleus;
 - nerve fibres that pass impulses towards the cell body;
 - nerve fibres that transmit impulses away from the cell body.
- Nerve: a bundle of nerve fibres surrounded by a tough, protective layer.
 - Each nerve fibre in a nerve is surrounded by an insulating layer.

OBJECTIVE 9

You must be able to state the structure and function of three types of nerve cells.

- Sensory neurons.
 - Function: to pass the impulses from the sense organs to the central nervous system.
 - Their cell bodies are near the central nervous system.
 - They have one long nerve fibre, which passes impulses to the cell body.
- Motor neurons.
 - Function: to pass impulses from the central nervous system to muscles or glands.
 - Their cell bodies are in the central nervous system.
 - They have one long nerve fibre, which passes impulses away from the cell body.
- Interneurons.
 - Function: to conduct impulses within the central nervous system:
 - Interneurons are entirely within the central nervous system.

OBJECTIVE 10

You must be able to describe what behaviour is and what causes behaviour. You must also be able to state what determines behaviour.

- Behaviour: everything that humans or animals do.
 - Behaviour consists of actions that are interrelated.
 - Together, these actions have a purpose. A lot of human and animal behaviour is based on increasing the chance of survival.
 - Behaviour chain: actions that have a fixed sequence, where the effect of one action leads to the next action.
- Behaviour is caused by stimuli.
 - Response: a reaction to a stimulus.
 - Internal stimulus: a stimulus that arises inside the body (e.g. hunger).
 - External stimulus: a stimulus that comes from outside the body.
 - Motivation: the willingness to react to stimuli.
- Behaviour is partly determined by hereditary factors and partly learned.

OBJECTIVE 11

You must be able to name some of the effects of alcohol.

- Alcohol affects the functioning of the nervous system and behaviour.
 - It temporarily reduces your sensory perception and reaction time.
- Young people are extra sensitive to the effects of alcohol and therefore:
 - have a higher chance of permanent brain damage;
 - run a greater risk of becoming addicted;
 - are more likely to get involved in aggression and violence;
 - run a higher risk of becoming involved in a traffic accident.

OBJECTIVE 12

You must be able to describe the structure and function of the endocrine system and name the key endocrine glands in an illustration.

- The endocrine system consists of a number of endocrine glands that produce hormones.
 - Many endocrine glands have no ducts: the hormones are released into the bloodstream.
 - Hormones control the function of tissues and organs that are sensitive to them.
 - Hormones also have an effect on metabolism, reproduction, growth and development.
- Locations of the major endocrine glands.
 - Pituitary: under the brain, between the two brain halves.
 - Thyroid: in the neck, in front of the larynx, up against the windpipe.
 - Islets of Langerhans: in the pancreas.
 - Adrenal glands: like caps on top of the kidneys.
 - Ovaries: in the abdominal cavity.
 - Testes: in the scrotum.

OBJECTIVE 13

You must be able to describe how the hormones from the islets of Langerhans work.

- The islets of Langerhans produce insulin and glucagon.
 - Insulin and glucagon control the blood glucose level (the blood sugar level). The glucose level is kept more or less constant.
 - When the blood glucose level is high, the islets of Langerhans produce a lot of insulin. Insulin makes the liver and muscles convert glucose into glycogen. Glycogen is stored.

- When the blood glucose level is low, the islets of Langerhans produce a lot of glucagon. Glucagon makes the liver and muscles convert glycogen into glucose. The glucose is taken up in the blood.
- Diabetes: too little insulin is produced and so the blood glucose level rises.
 - Glucose may then be excreted in the urine.

EXTRA OBJECTIVE 14

You must be able to name the parts of the brain with their functions and characteristics.

- The brain consists of the cerebrum, the cerebellum and the brainstem.
- The structure of the cerebrum and the cerebellum:
 - cortex: on the outside, grey coloured, contains a lot of cell bodies of interneurons;
 - medulla: on the inside, lighter in colour, contains a lot of nerve fibres of interneurons.
- Functions of the cerebrum:
 - processing impulses from the senses (conscious sensation);
 - controlling voluntary movements (conscious responses).
- Brain centres: parts of the cerebrum with special functions.
 - Incoming impulses are processed in the sensory centres (auditory cortex and visual cortex, for example). The location where impulses arrive and are processed determines which stimulus you will be aware of.
 - Impulses for voluntary movements (conscious responses) are created in motor centres (writing and speech centres, for example).
- Function of the cerebellum:
 - coordination of movements (including keeping your balance).
- Functions of the brainstem:
 - conducting impulses from the spinal cord to the cerebrum and cerebellum, and vice versa;
 - conducting impulses from the nerves in the head and neck to the cerebrum and cerebellum, and vice versa.

EXTRA OBJECTIVE 15

You must be able to describe what a reflex is and you must be able to describe a reflex arc.

- Reflex: is a fixed, rapid and involuntary response to a certain stimulus.
 - The speed is often needed to protect the body against injuries.
 - Examples: withdrawal reflex, patellar (knee-jerk) reflex, blink reflex, pupillary light reflex.
- Reflex arc: the path taken by the nerve impulses in a reflex.
 - Stimuli lead to impulses in the nerve cells.
 - The impulses are passed to interneurons in the spinal cord or in the brainstem via sensory neurons.
 - Interneurons immediately pass the impulses to motor neurons.
 - Motor neurons pass impulses to muscle cells, causing muscles to contract.
 - The reflex arcs of the head and neck go via the brainstem.
 - The reflex arcs of the torso and the limbs go via the spinal cord.

SKILLS AND COMPETENCIES**BASICS**

- You have learned how to demonstrate the blind spot.
- You have learned how to demonstrate the pupillary light reflex.
- You have practised carrying out an investigation.
- You have practised making a table of results.
- You have practised drawing conclusions.
- You have practised getting information from articles.

EXTRA

- You have learned how to test someone's patellar reflex.

The diagnostic test does not include any questions about these skills and competencies.

You have met an optometrist in this unit. You have also seen applications of biology in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

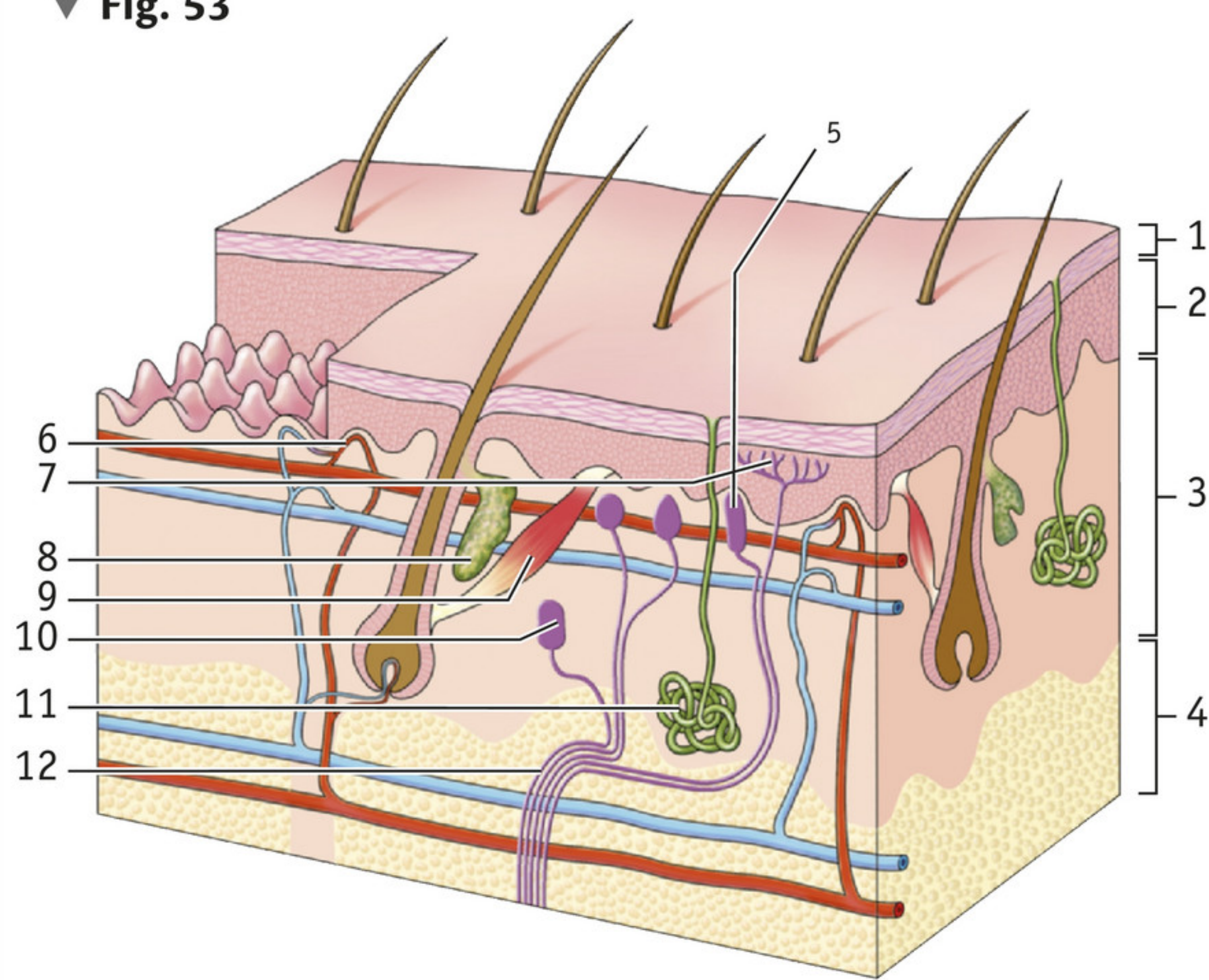
Say whether each of the following statements is true or false.

- 1 A sense organ is an organ that reacts to certain influences from the environment.
- 2 Information from the environment that has an effect on an organism is called an impulse.
- 3 The threshold value of a sensory cell is the lowest intensity of stimulus that results in an impulse.
- 4 A sensory cell that is particularly sensitive to a certain stimulus has a high threshold value for that stimulus.
- 5 An adequate stimulus is a stimulus below the threshold value.
- 6 Habituation means that you stop feeling the pressure of your clothes on your body.
- 7 Pressure receptors are found in the ears.

OBJECTIVE 2

Figure 53 shows a schematic drawing of a cross section of the skin and the subcutaneous tissue. Answer the following questions.

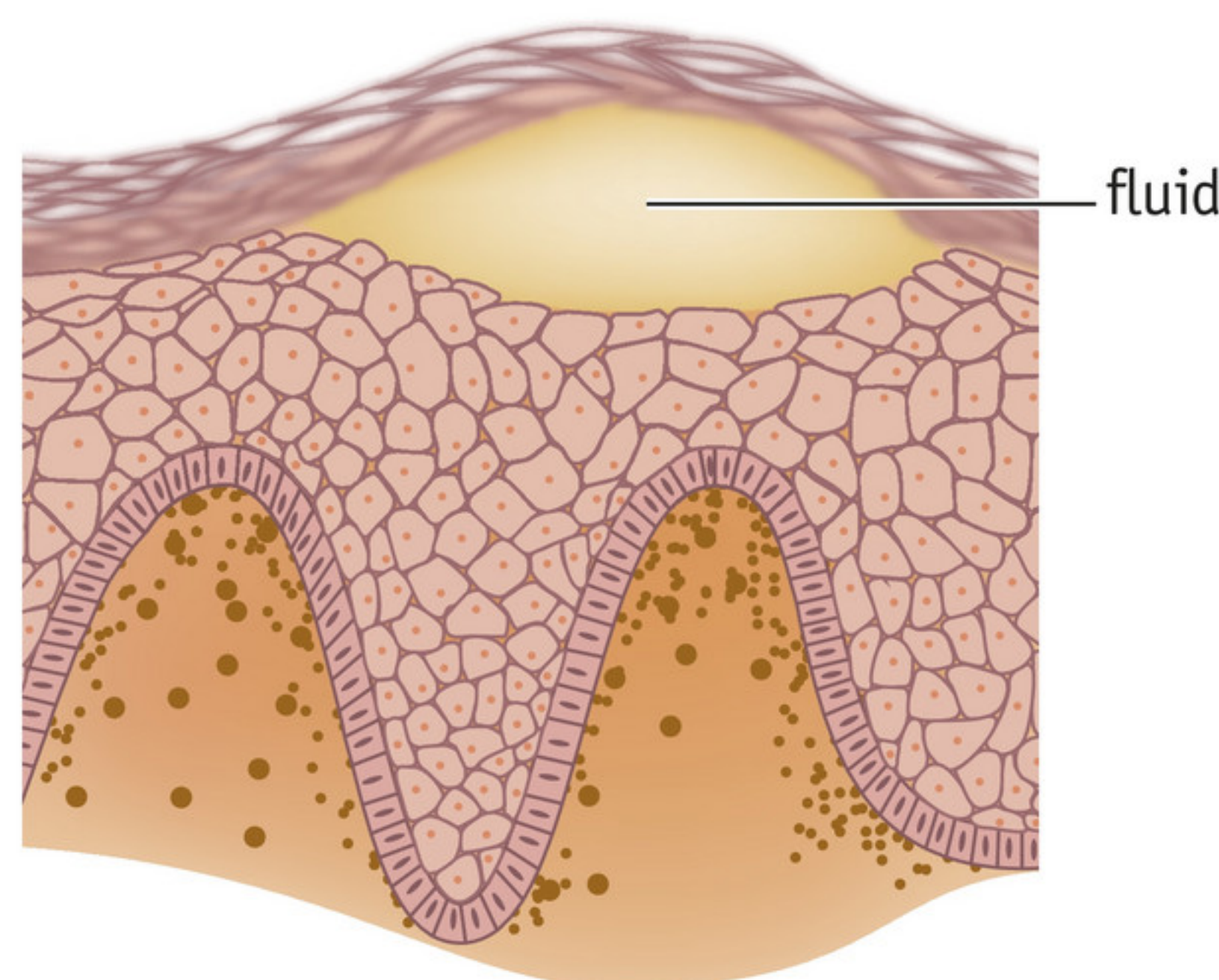
▼ Fig. 53



- 1 Which number shows a pain receptor?
- 2 Which number shows the layer that protects against dehydration?

- 3 Which of the numbered layers contains stored fat?
- 4 In which of the numbered layers does cell division occur most?
- 5 Which number indicates the part of the skin in which impulses are created after a light touch?
- 6 Which number indicates the part of the skin that produces a substance that cools down the body?
- 7 If someone's hair gets greasy quickly, what substance is being produced a lot in the skin on that person's head?
- 8 Almost everyone gets infected with the chicken pox virus as a toddler. The symptoms of chicken pox are fever, vesicles on the skin and itchiness. The vesicles are caused by fluid that collects between two layers of the skin (see figure 54). State the names of the two layers that the fluid of such a vesicle is found between.

▼ Fig. 54



- 9 A tick is an arthropod that feeds on the blood of birds and mammals. Ticks can also bite into the skin of humans and suck out blood containing nutrients (see figure 55). What is the name of the skin layer that ticks suck nutrients from?

▼ Fig. 55

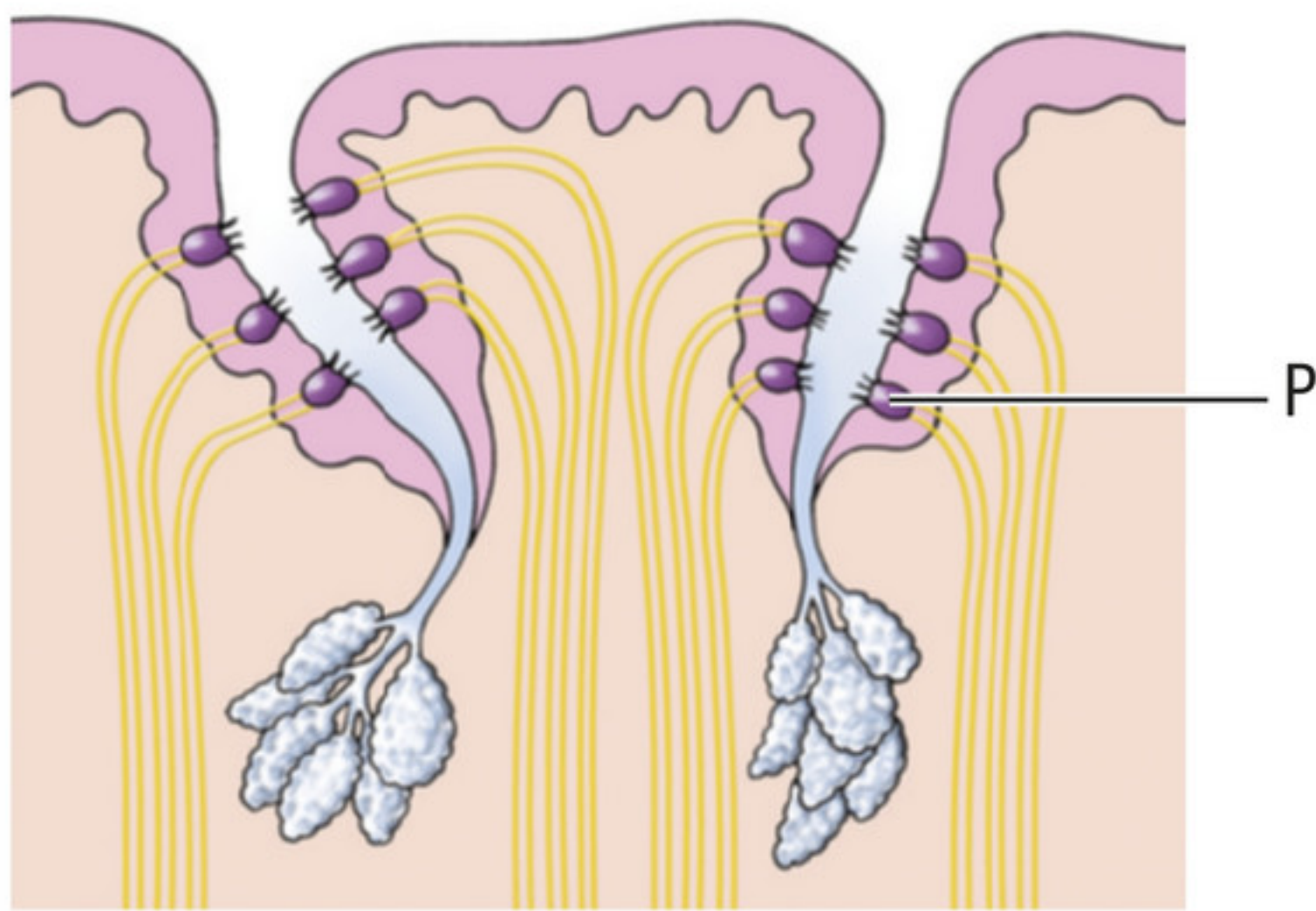


OBJECTIVE 3

Say whether each of the following statements is true or false.

- 1 Figure 56 shows a touch receptor indicated by the letter P.
- 2 If you keep your eyes and nose closed, this will let you taste things better.
- 3 If you have a cold, you cannot taste things so well.
- 4 A single taste bud on your tongue can distinguish between four flavours.

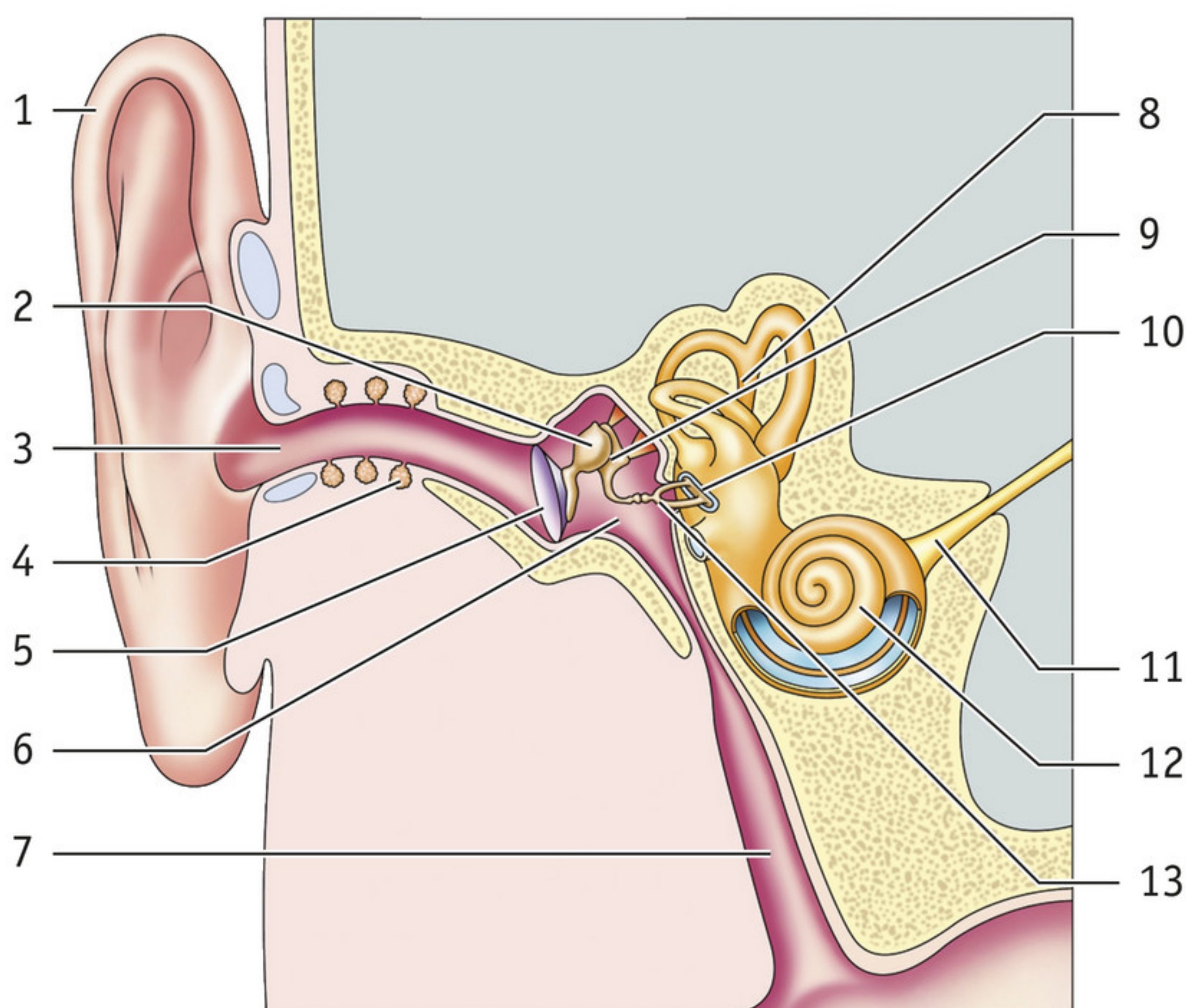
▼ Fig. 56

**OBJECTIVE 4**

Answer the following multiple choice questions.

- 1 Figure 57 shows a schematic drawing of a cross section of an ear.
Through which parts of the ear do sound vibrations pass and in which order?
 A from part 5 via part 6 to part 12.
 B from part 5 via part 2 to part 9.
 C from part 9 via part 7 to part 9.
 D from part 9 via part 6 to part 12.

▼ Fig. 57



- 2 Wibi Soerjadi is a famous Dutch concert pianist. In 2009, part of his hearing became temporarily affected. That part is indicated by number 11 in figure 57. Because part 11 became affected, the sound that Wibi heard was distorted and so he heard a different sound to what he was playing. Two pupils make statements about the cause of the distorted sound that Wibi heard. Justine says that sound vibrations in Wibi's hearing were distorted. Zeke says that impulses were not passed properly to Wibi's brain. Who is right?
 A Neither of them
 B Only Justine.
 C Only Zeke.
 D Both Justine and Zeke.
- 3 Figure 58 tells you how loud noises can damage parts of the ear.
In which of the numbered parts in figure 57 does this damage occur?
 A In part 5.
 B In part 10.
 C In part 11.
 D In part 12.

▼ Fig. 58

Young people do little to prevent hearing damage

AMSTERDAM - Almost three quarters of young people are aware that they run the risk of getting hearing damage if they are exposed to noise from MP3 players, discos, DJ parties or festivals for too long, but they do nothing to prevent that damage. Hearing damage caused by noise happens when the hairs of sensory cells in the ears are damaged by the loud noises.

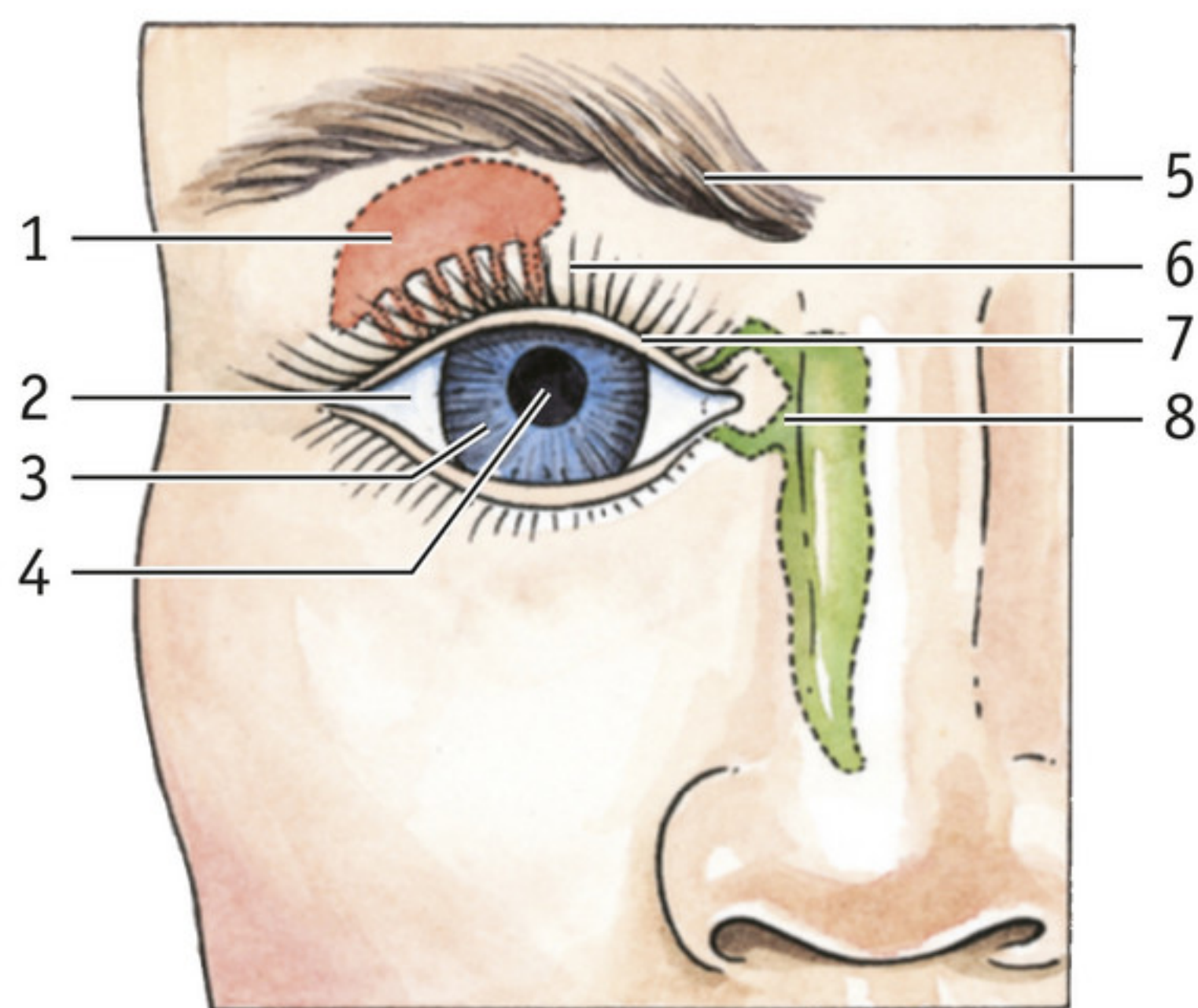


OBJECTIVE 5

Answer the following multiple choice questions.

- 1 Figure 59 shows a part of a face. Some parts have been numbered.
- Which of the numbered parts protect the eye against light that is too bright?
- A** Only part 5.
B Only parts 3 and 6.
C Only parts 3, 4 and 5.
D Parts 3, 4, 5 and 6.

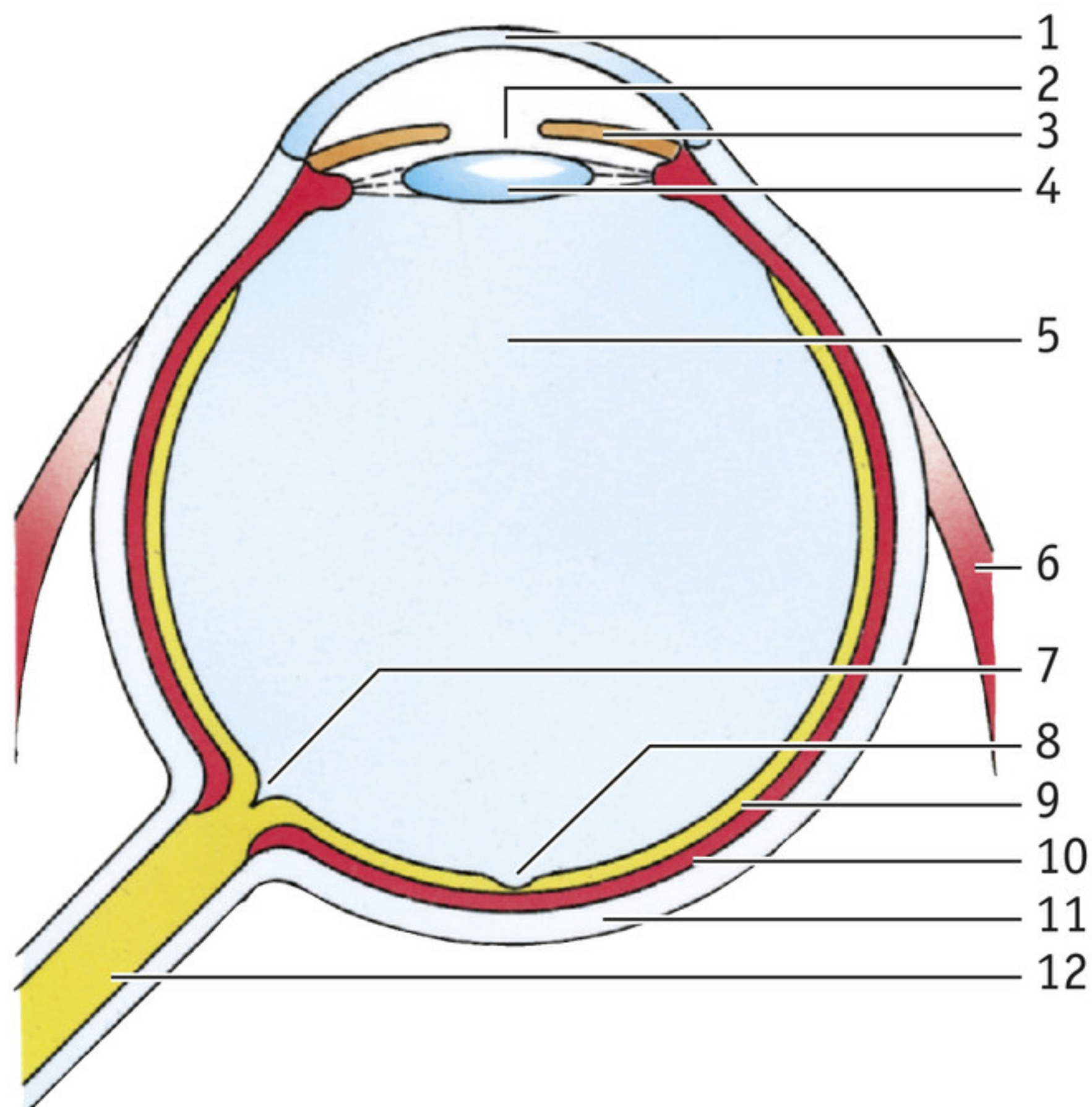
▼ Fig. 59



- 2 Figure 60 shows a schematic drawing of a cross section of an eye.
- Which part of the eye in particular is there to protect the inner parts?
- And which part in particular is responsible for the nutrition of much of the eye?

Protection	Nutrition:
A part 6	part 10
B part 6	part 11
C part 11	part 6
D part 11	part 10

▼ Fig. 60



- 3 Do parts 7 and 9 contain sensory cells?
- If so, is there a difference between the number of sensory cells in these parts?
- A** Neither part has sensory cells.
B Both parts have the same number of sensory cells.
C Part 7 has more sensory cells than part 9.
D Part 9 has more sensory cells than part 7.

- 4 Here are four parts of a human eye:

- 1 vitreous body;
- 2 cornea;
- 3 lens;
- 4 pupil.

Rays of light make the retina produce impulses.

Which of the parts mentioned do the light rays cross before reaching the retina, and in what order?

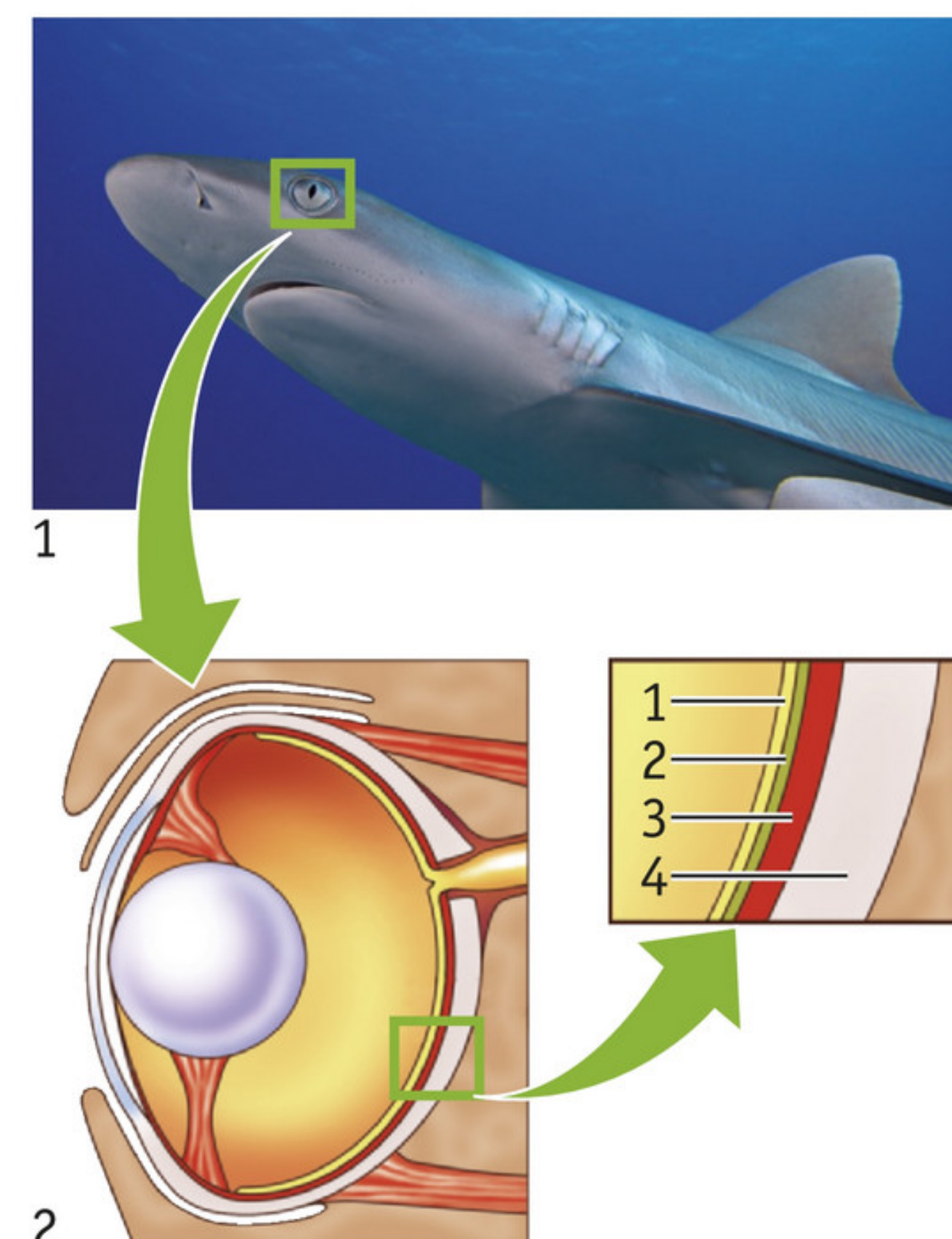
- A** 2 - 4 - 1 - 3.
B 2 - 4 - 3 - 1.
C 3 - 4 - 1.
D 3 - 2 - 4.

- 5 Many sharks are particularly active when there is little light. The structure of a shark's eye is almost the same as that of a human eye. A shark's eye has an extra layer right behind the retina, called the *tapetum*. The tapetum reflects the light that does not fall directly onto the sensory cells of the retina back towards the sensory cells. This lets the shark see well enough when there is little light. Figure 61.2 shows a schematic drawing of a cross section of a shark's eye.

Which number indicates the tapetum?

- A** 1.
B 2.
C 3.
D 4.

▼ Fig. 61

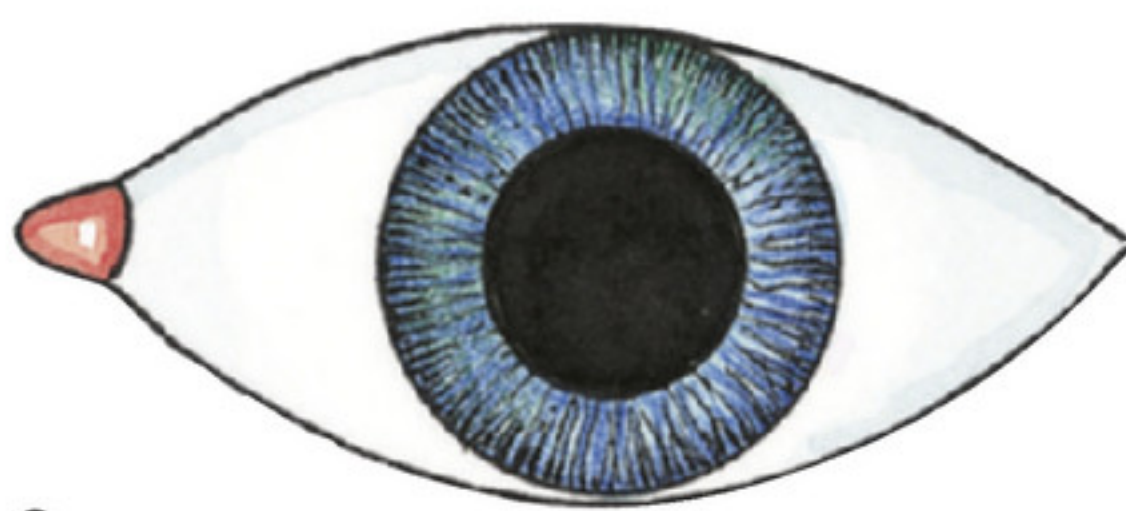
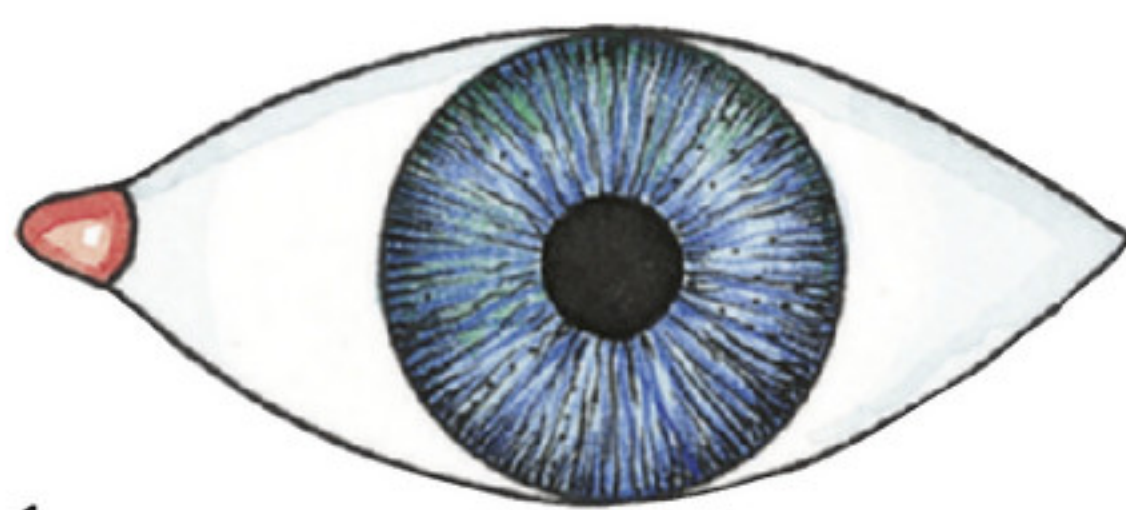


OBJECTIVE 6

Answer the following two-choice questions.

- 1 What is the function of the pupillary light reflex?
 - A To control the amount of light reaching the retina.
 - B To make sure that you can see sharply.
- 2 Oliver walks his dog every evening. One evening it is very dark. There are no lights to be seen. Suddenly the bright light of an approaching car shines into his eyes. He walks on half-blinded. Figure 62 shows one of Oliver's eyes twice, as it looked like during his walk. Which of these drawings most likely shows the size of Oliver's pupils before the bright light shone into his eyes?
 - A Drawing 1.
 - B Drawing 2.

▼ Fig. 62



- 3 At the moment that the bright light from the car shone into Oliver's eyes, the pupillary light reflex occurred in his eyes. Which muscles in Oliver's irises were contracting at that moment?
 - A The circular muscles.
 - B The radial muscles.
- 4 Figure 63 shows a photo of a someone's eye. Which muscles of this eye were relaxed at the moment the photo was taken?
 - A The circular muscles.
 - B The radial muscles.

▼ Fig. 63

**OBJECTIVE 7**

Say whether each of the following statements is true or false.

- 1 The central nervous system consists of the brain, the spinal cord and nerves.
- 2 Your tongue is connected to your brain by a nerve.
- 3 There is a nerve running from your left hand to your brain.
- 4 The nervous system can control the function of a salivary gland.

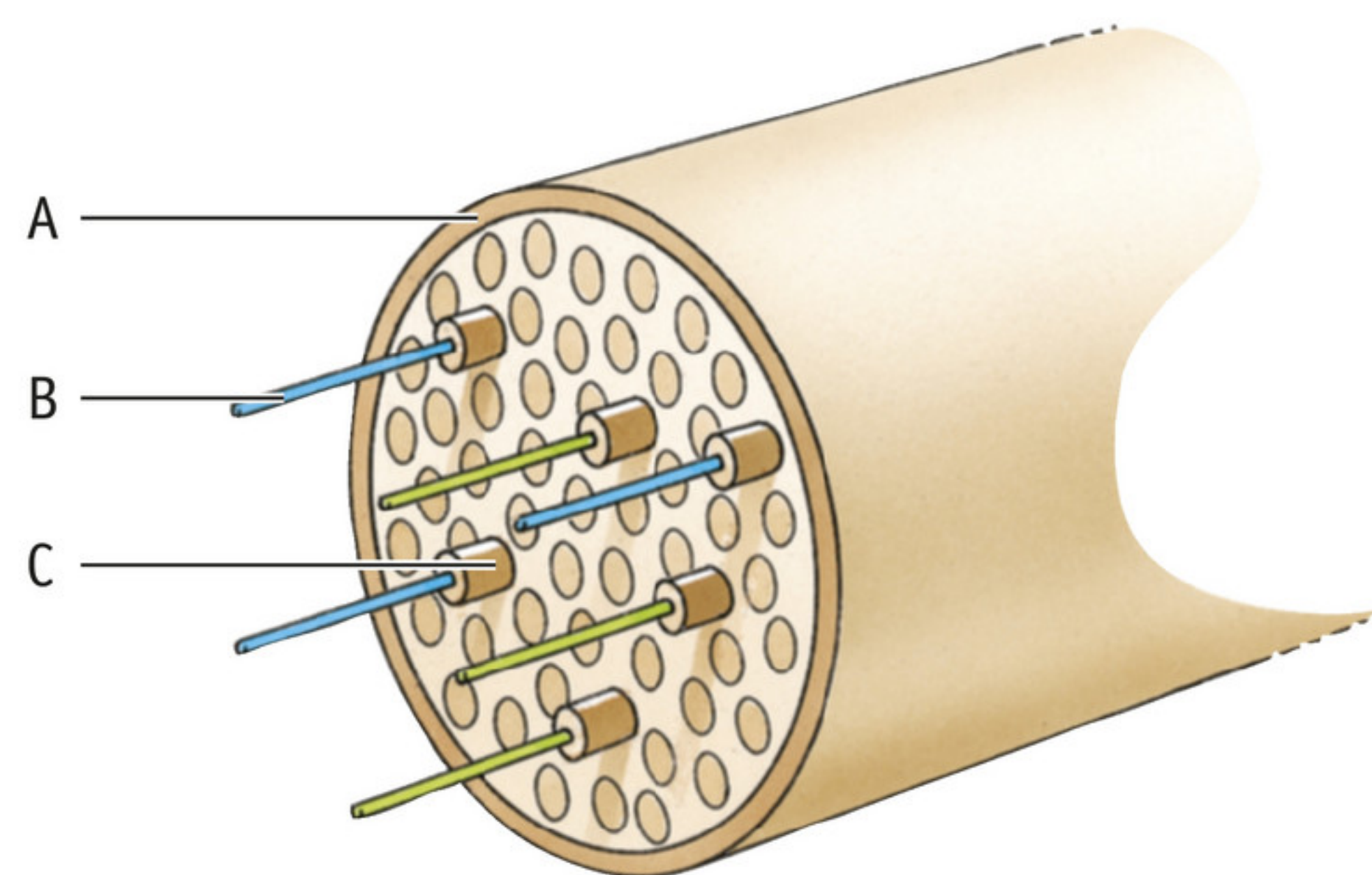
OBJECTIVE 8

Answer the following questions.

Figure 64 shows a schematic drawing of a nerve.

- 1 Which letter indicates a nerve fibre of a nerve cell?
- 2 What is the function of part C?
- 3 What is the function of part A?

▼ Fig. 64

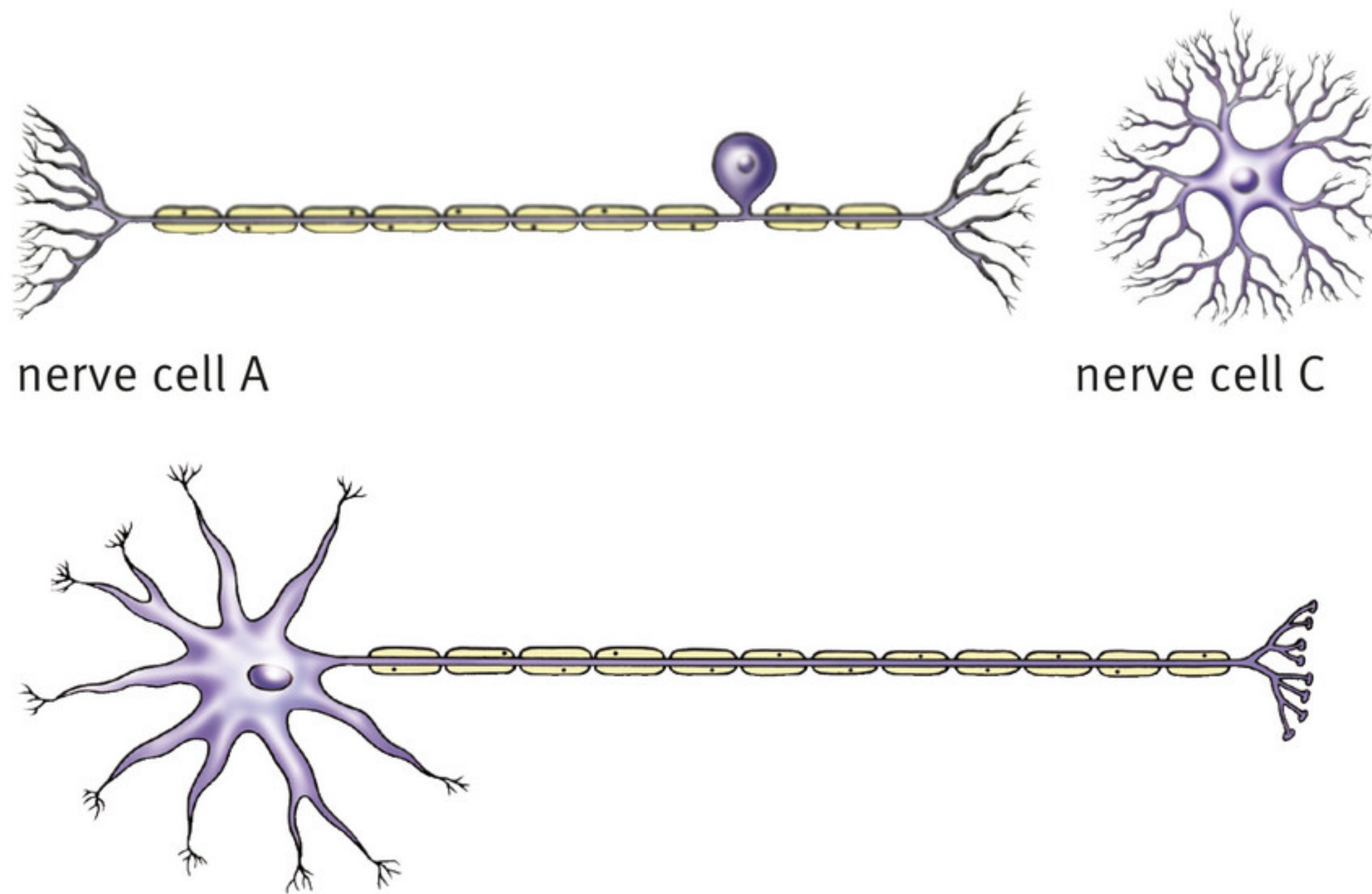


OBJECTIVE 9

Figure 65 shows three types of nerve cell. The score sheet shows a table with the three types of nerve cell. Answer the following questions by putting crosses in the correct column or columns.

- 1 What type of nerve cell is nerve cell A?
- 2 What type of nerve cell is nerve cell B?
- 3 What type of nerve cell is nerve cell C?
- 4 Which nerve cells pass impulses from the central nervous system to glands?
- 5 Which nerve cells have cell bodies that are outside the central nervous system?
- 6 Which nerve cells have one long nerve fibre that carries impulses towards the cell body?
- 7 Which nerve cells are found in a human head?

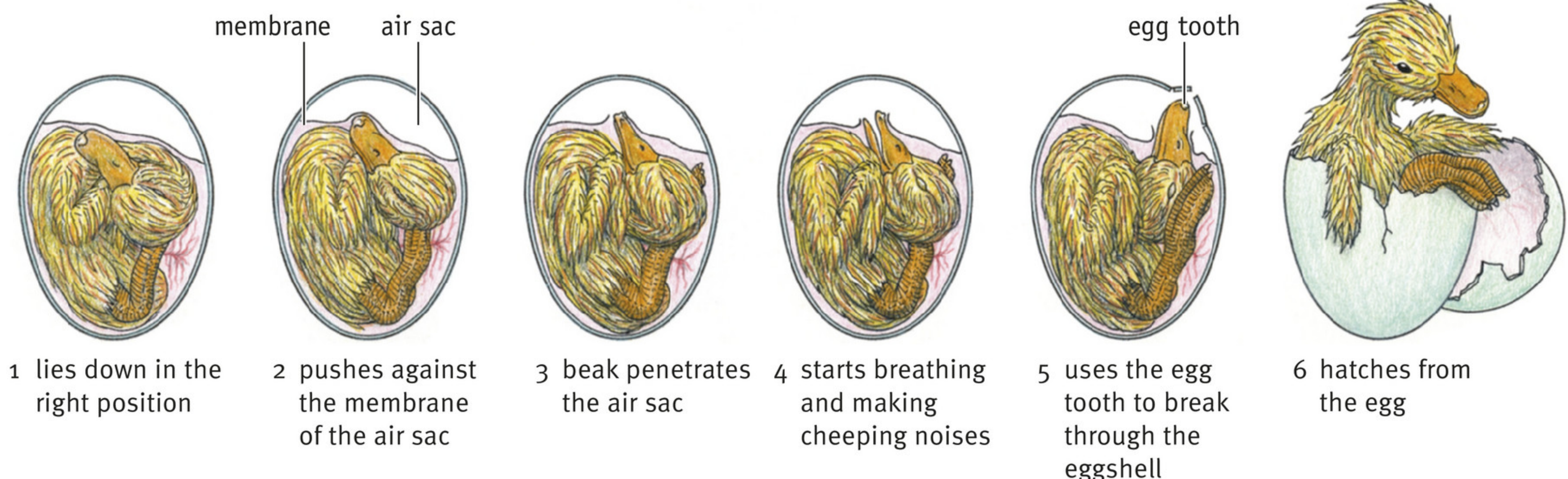
▼ Fig. 65



nerve cell B

If a foal gets hungry, it starts sucking the teats of the mare (the mother horse). As soon as the foal starts sucking (see figure 66), this will stimulate the sense organs in the teats. These sense organs pass impulses to the spinal cord of the mare.

▼ Fig. 67



These impulses trigger the production of a hormone in the head of the horse.

- 8 Which type of nerve cells pass the impulses that are created by sucking to the spinal cord?
- 9 Which type of nerve cells pass the impulses from the spinal cord to the head of the mare?

▼ Fig. 66

**OBJECTIVE 10**

Answer the following questions.

- 1 Figure 67 shows the behaviour of a duckling during its final days in the egg and when it hatches from the egg. Explain using behaviours 3 and 4 why you can call actions 1 to 6 a behaviour chain.
- 2 Are actions 1 to 6 only determined by hereditary factors, only learned, or both determined by hereditary factors and learned?

The following information is for questions 3 and 4.

A duckling is bitten on its leg by a pike (a large fish). The duckling does not see the pike, but it peeps loudly and tries to swim away.

- 3 Is this peeping caused by an internal stimulus or by an external stimulus?
- 4 What is the duckling's response?

OBJECTIVE 11

Say whether each of the following statements is true or false.

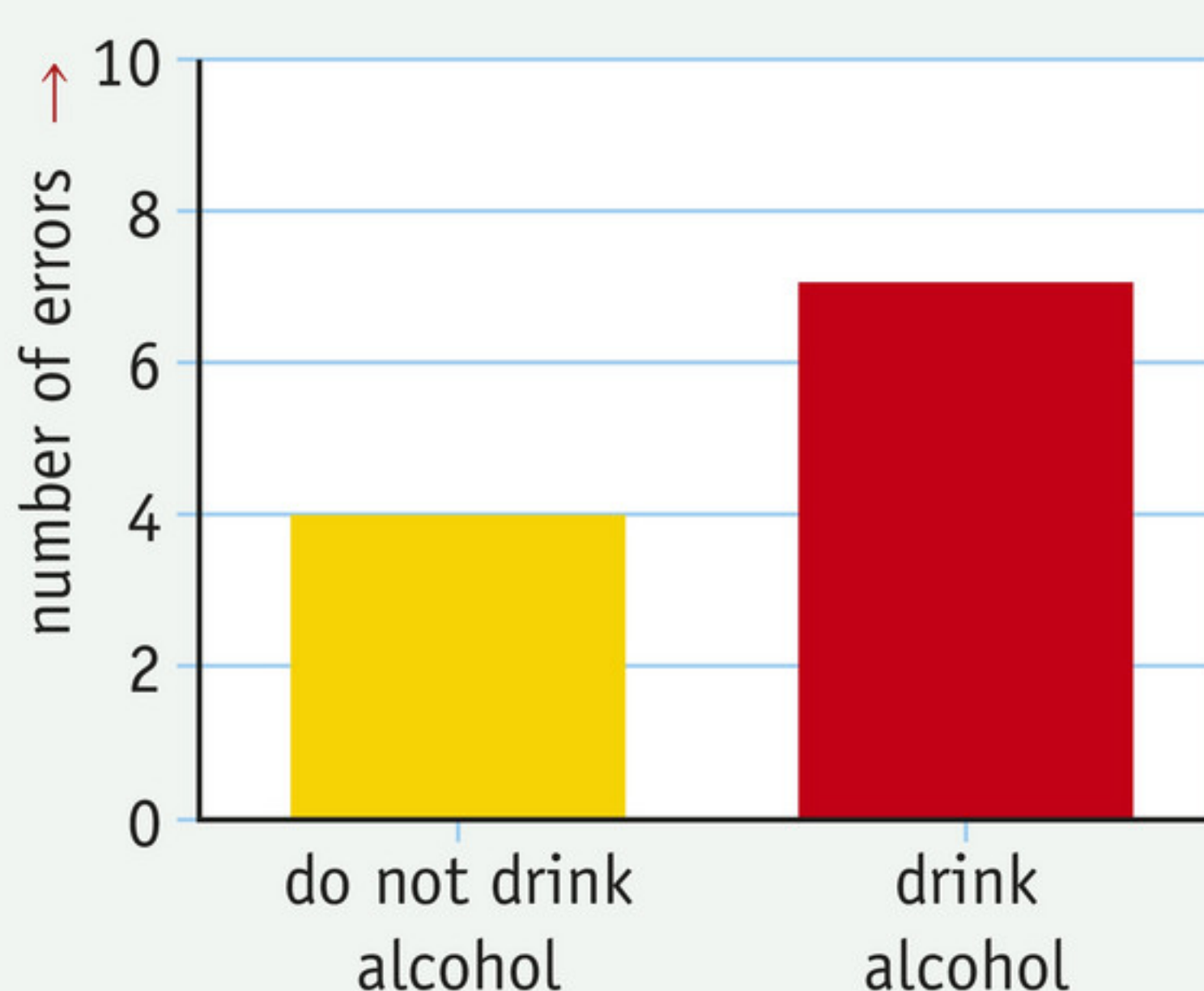
- 1 Figure 68 shows that drinking alcohol causes brain damage in young people.
- 2 Figure 68 shows that drinking lots of alcohol causes permanent brain damage in young people.
- 3 If people aged 15 to 25 drive a vehicle after drinking as much alcohol as people aged 40 to 50, they run an equal risk on average of having an accident.
- 4 Young people who start drinking alcohol regularly at the age of 14 have an equal chance of becoming addicted to alcohol as young people who start drinking alcohol regularly at the age of 20.

▼ Fig. 68

The effect of alcohol on young people's learning abilities

Scientists investigated the effect of alcohol on the learning abilities of young people aged about 20. Two groups of young people were tested. The young people from one group regularly drank five glasses of alcohol or more at a time. The young people from the other group did not drink alcohol. During the two weeks before the test, no one was allowed to drink alcohol anymore.

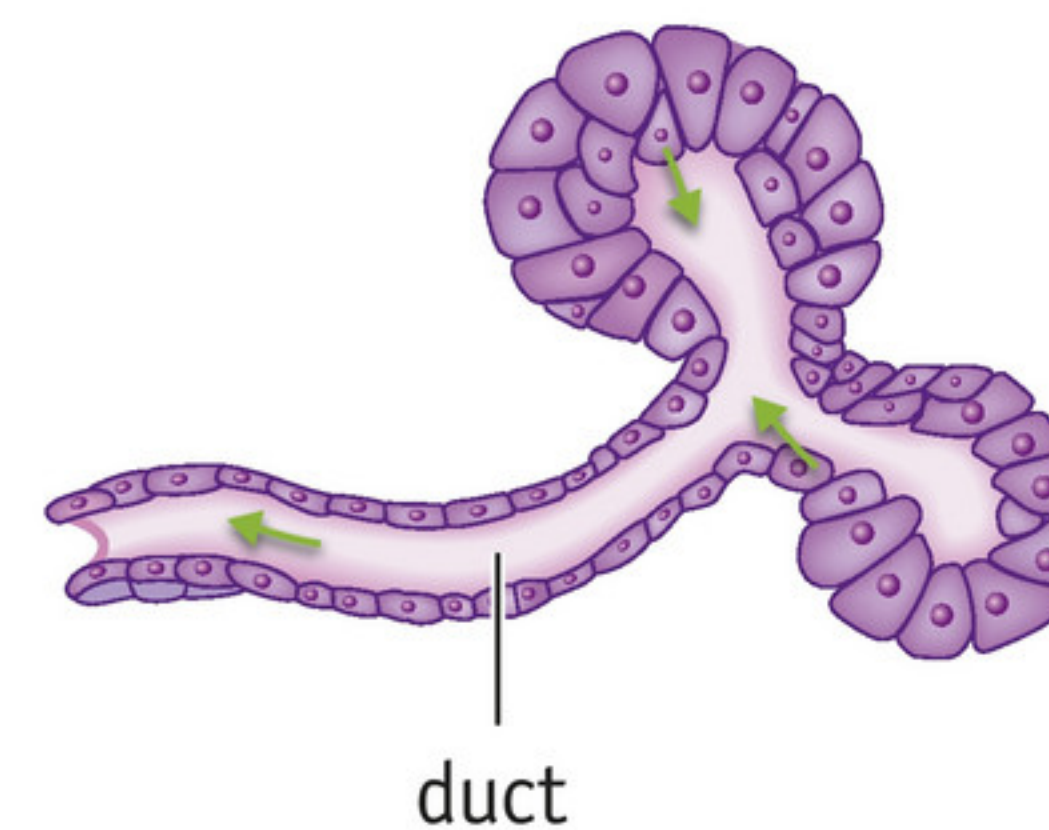
The test was about learning groups of paired words. The young people were tested on the words they had learned: they heard one word and had to state the other. The average number of errors was calculated for both groups (see the graph).

**OBJECTIVE 12**

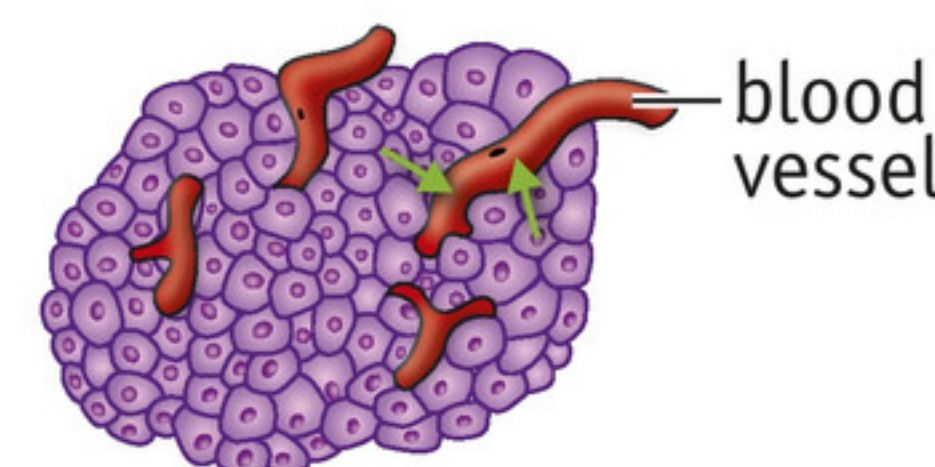
Answer the following multiple choice questions.

- 1 What is the function of hormones?
 - A Hormones regulate the functioning of tissues and organs that are sensitive to them.
 - B Hormones process impulses from the sensory cells.
 - C Hormones provide the nutrients for many endocrine glands.
 - D Hormones regulate fixed, rapid responses to certain stimuli.
- 2 Figure 69 shows two glands. Which of these two glands is most likely to be the thyroid?
 - A Neither of them.
 - B Only gland 1.
 - C Only gland 2.

▼ Fig. 69



gland 1



gland 2

- 3 Three of the endocrine glands are an adrenal gland, an islet of Langerhans and the thyroid. Which of these endocrine glands is located nearest to the pituitary in the body?
 - A The adrenal gland.
 - B The islet of Langerhans.
 - C The thyroid.

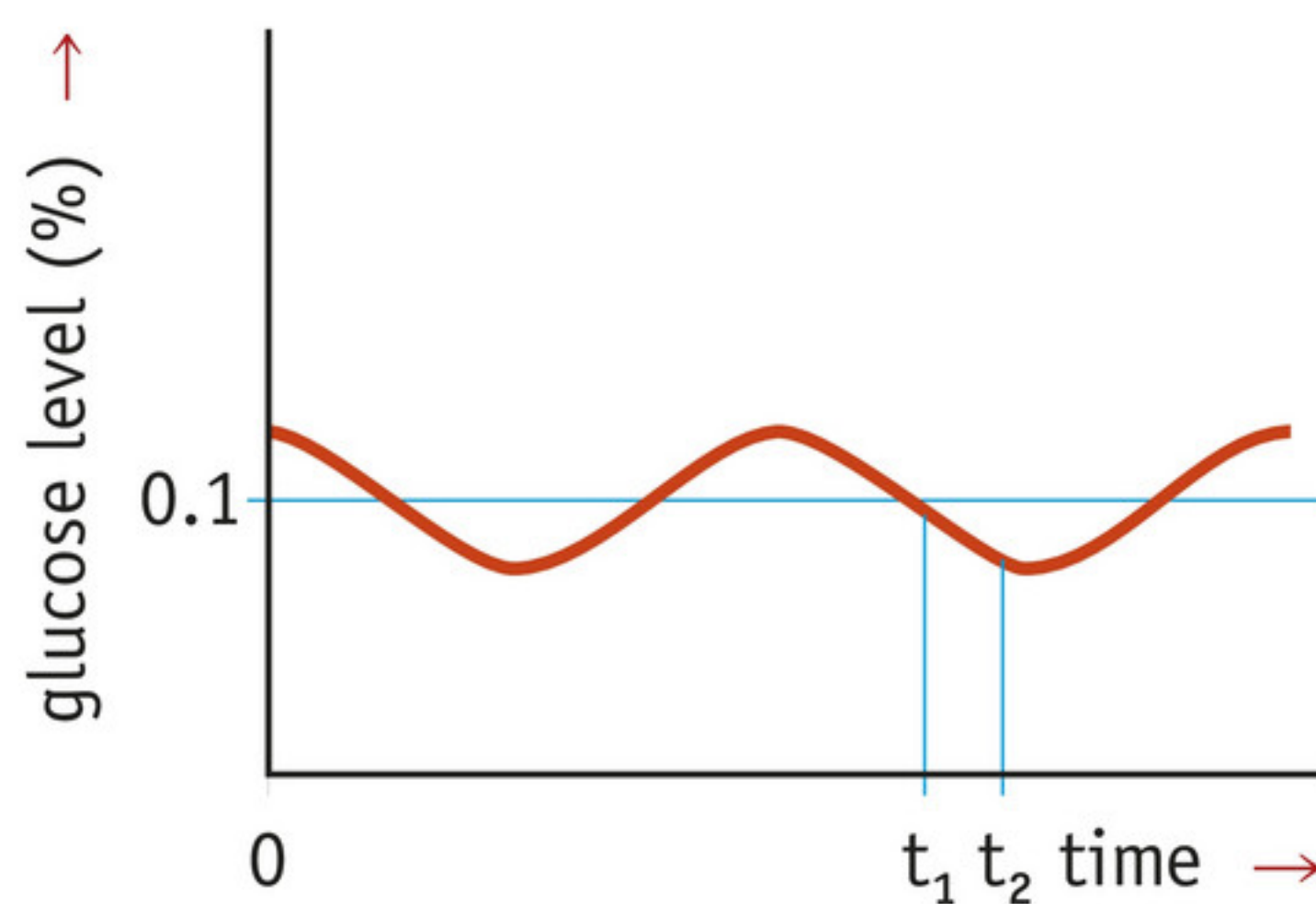
OBJECTIVE 13

Answer the following two-choice questions.

- 1 What is the effect of insulin on the blood glucose level?
 - A Insulin increases the blood glucose level.
 - B Insulin decreases the blood glucose level.

- 2 Human blood contains 0.1% glucose on average. When do the islets of Langerhans produce a lot of insulin?
- A When the blood glucose level is higher than 0.1%.
- B When the blood glucose level is lower than 0.1%.
- 3 Somebody has their blood glucose level measured for a certain period of time. The relationship between the blood glucose level and time is shown in a graph (see figure 70). What hormone's level in the blood decreases between times t_1 and t_2 ?
- A Insulin.
- B Glucagon.

▼ Fig. 70



- 4 What hormone is not produced in sufficient quantities in diabetes?
- A Insulin.
- B Glucagon.

EXTRA OBJECTIVE 14

Answer the following multiple choice questions.

- 1 Parts of the brain include:
- 1 motor centres in the cerebral cortex;
 - 2 sensory centres in the cerebral cortex;
 - 3 the brainstem;
 - 4 the cerebellum.
- Which of these parts are used when you are typing a message on your mobile?
- A Only parts 1 and 2.
- B Only parts 2 and 3.
- C Only parts 1, 3 and 4.
- D Parts 1, 2, 3 and 4.

- 2 Figure 71 shows an article. Does this article show that alcohol has an effect on the cerebrum? And on the cerebellum?
- A Not on the cerebrum and not on the cerebellum either.
- B Only on the cerebrum.
- C Only on the cerebellum.
- D On both the cerebrum and the cerebellum.

▼ Fig. 71

Emergency stop

Jack had drunk a lot of beer when he went out one evening. It made him a bit reckless and so he still got into his car to drive home. He did not realise that he was hearing everything less well and reacting more slowly, and that the alcohol had reduced his ability to coordinate his muscles.

Soon enough, he ended up 'parking' his car in a tree. Fortunately, Jack escaped unharmed.

Two hours after the accident, he was still not able to stand steadily. He still had trouble speaking and was speaking unclearly.



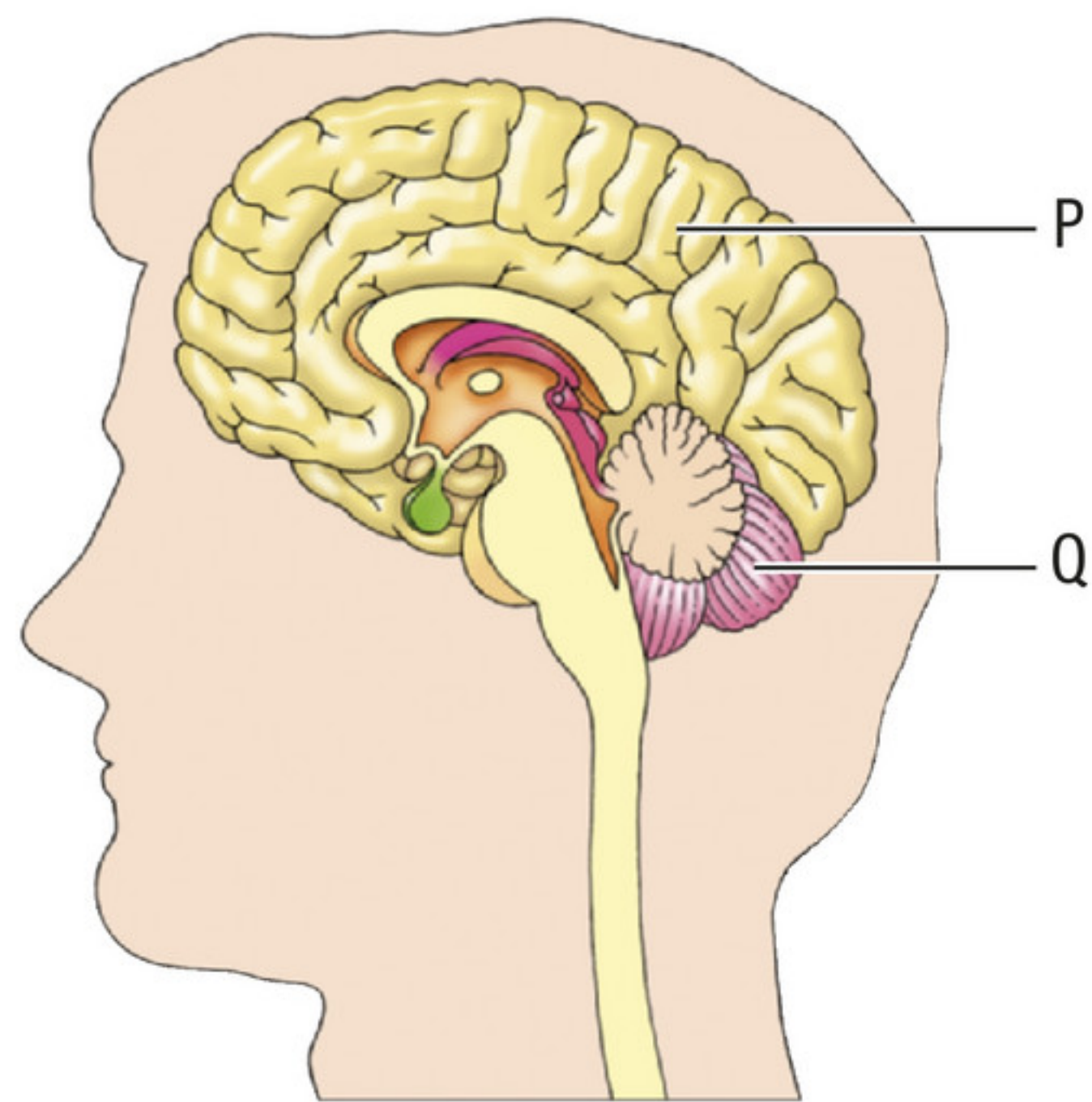
- 3 You see a mosquito on your arm and you feel it bite you. The mosquito sucks up some blood. When you see the mosquito, impulses from your eyes have arrived in the cerebrum. Did these impulses go through the spinal cord? When you feel it bite, impulses from the skin of your arm have arrived in the cerebrum. Did these impulses go through the spinal cord?

	<i>When seeing</i>	<i>When feeling</i>
A	yes	yes
B	yes	no
C	no	yes
D	no	no

- 4 Figure 72 shows a schematic drawing of a head and brain. Someone turns their head after hearing a loud bang. Where in the brain does conscious sensation occur? And where in the brain are the impulses for moving the head generated?

	<i>Conscious sensation in</i>	<i>Impulses generated in</i>
A	part P.	part P.
B	part P.	part Q.
C	part Q.	part P.
D	part Q.	part Q.

▼ Fig. 72

**EXTRA OBJECTIVE 15**

Answer the following multiple choice questions.

- 1 Here are three movements that you can make with your leg.
- Lifting up your leg quickly when a nail goes through the sole of your shoe into your foot.
 - Bending your leg to let you tie your shoelaces.

- 3 Moving your leg unconsciously while standing up straight to avoid losing your balance.

Which of these movements of your legs are reflexes?

- A Only movements 1 and 2.
B Only movements 1 and 3.
C Only movements 2 and 3.
D Movements 1, 2 and 3.

Someone gets a burn from hot water and pulls back his hand in a reflex (see figure 73). Questions 2 and 3 are about this reflex.

▼ Fig. 73



- 2 The following types of cells are used in the reflex in figure 73:

- motor neurons;
- sensory neurons;
- interneurons;
- muscle cells;
- sensory cells.

In what sequence are these cells involved during the reflex?

- A 2 – 5 – 4 – 3 – 1.
B 4 – 1 – 3 – 2 – 5.
C 5 – 1 – 2 – 3 – 4.
D 5 – 2 – 3 – 1 – 4.

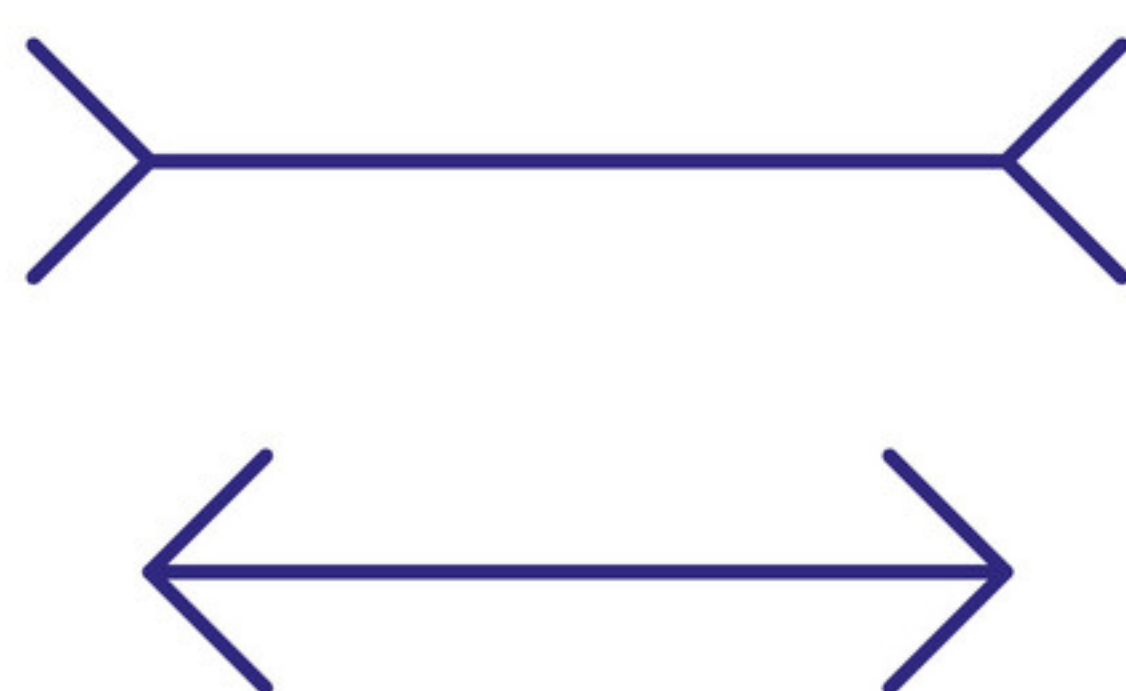
- 3 Where are the interneurons in this reflex arc?

- A in the cerebrum.
B in the cerebellum.
C in the brainstem.
D in the spinal cord.

You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three topics. You can do the exercises for them in your workbook.

1 Optical illusions

▼ Fig. 74



The brain processes the impulses that come from the senses. That processing can sometimes misfire a bit. If you think you see things that are not really there, it may be caused by an **optical illusion**. This extension will teach you a few examples of optical illusions.

Figure 74 shows you a well-known example of an optical illusion. It looks as if the horizontal line in the top figure is longer than the horizontal line in the bottom figure. If you measure both lines, though, they turn out to be equally long.

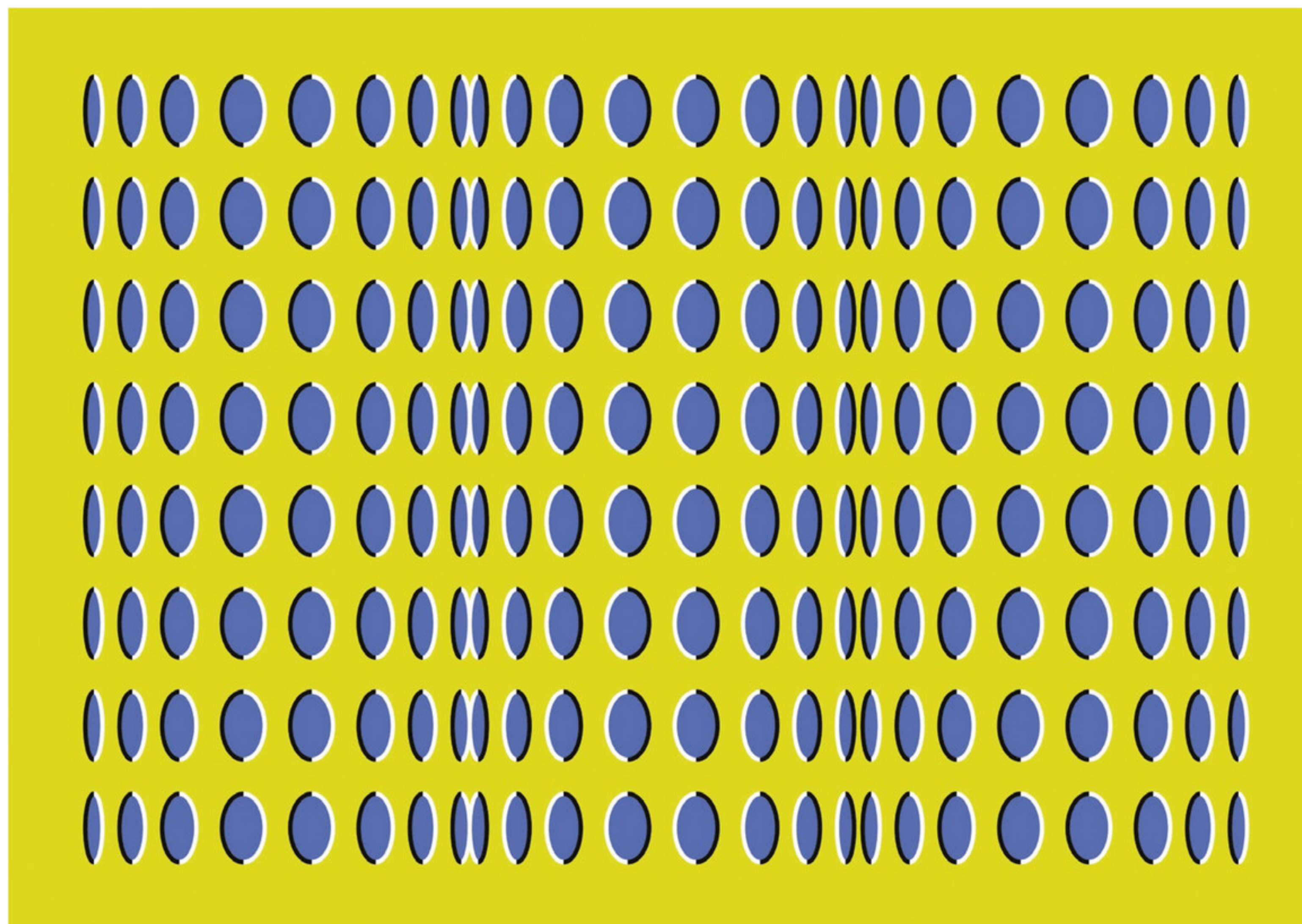
Optical illusions can also occur because of the surroundings that the figures are placed in. Figure 75 shows three girls. The girl on the right of the picture seems to be bigger than the girl at the bottom left. Figure 76 shows an example of an illusion that appears to move. And there are figures that look normal at first glance, but then turn out to be impossible (see figure 77). Figure 78 shows you a puzzle in which an optical illusion plays a part.

WB EXERCISE 1, PAGE 77

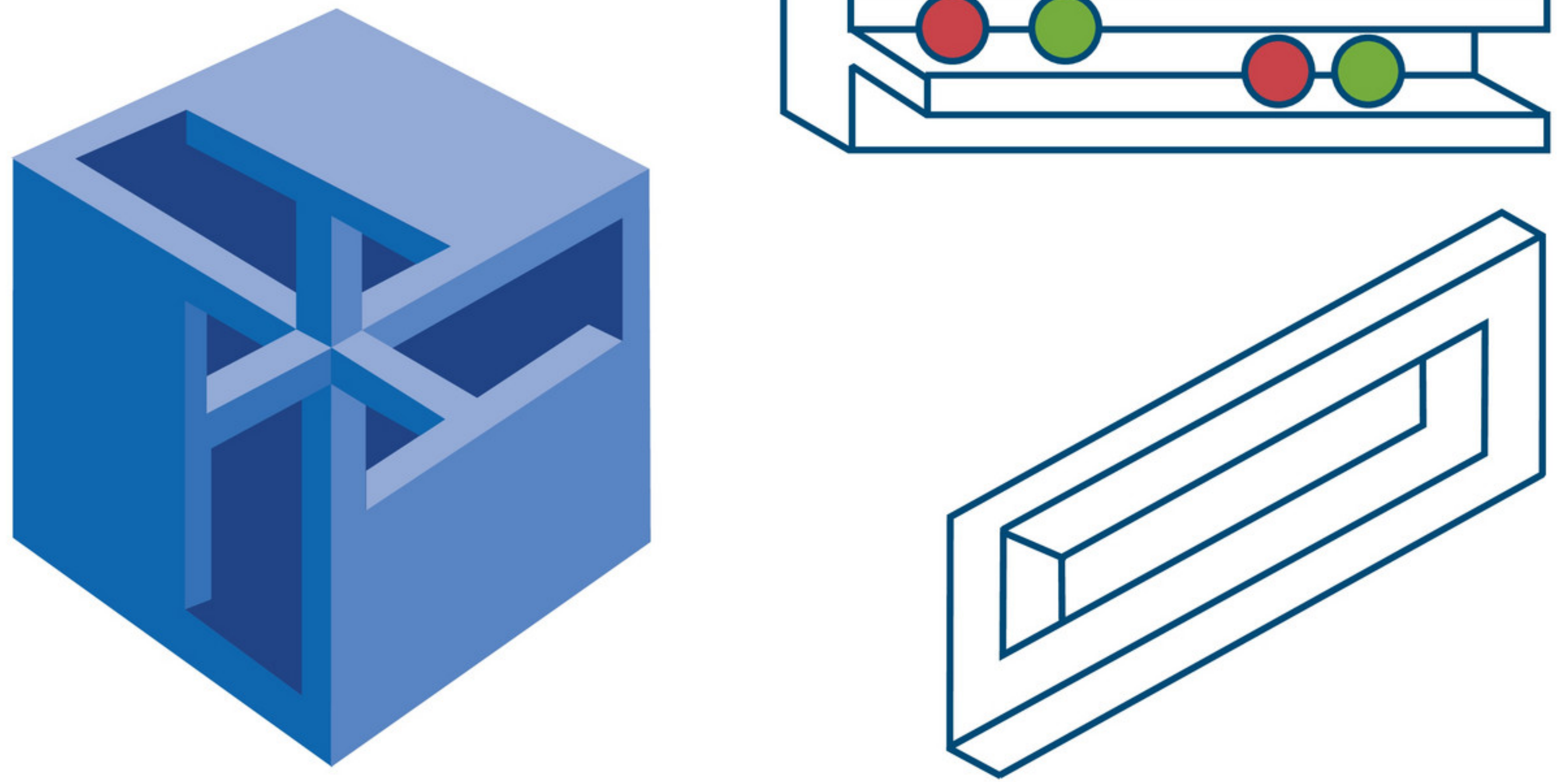
▼ Fig. 75



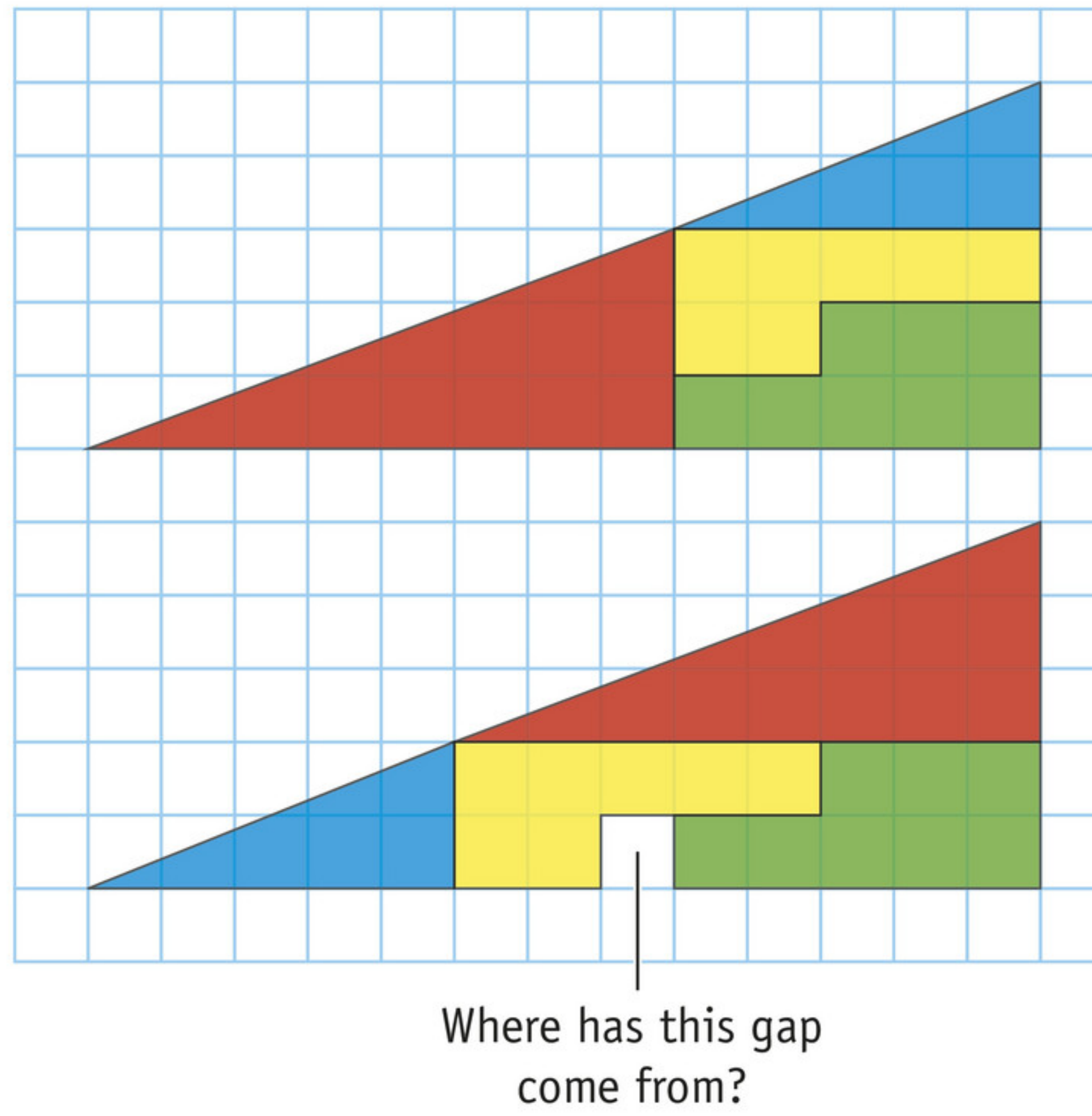
▼ Fig. 76



► **Fig. 77** Impossible figures.

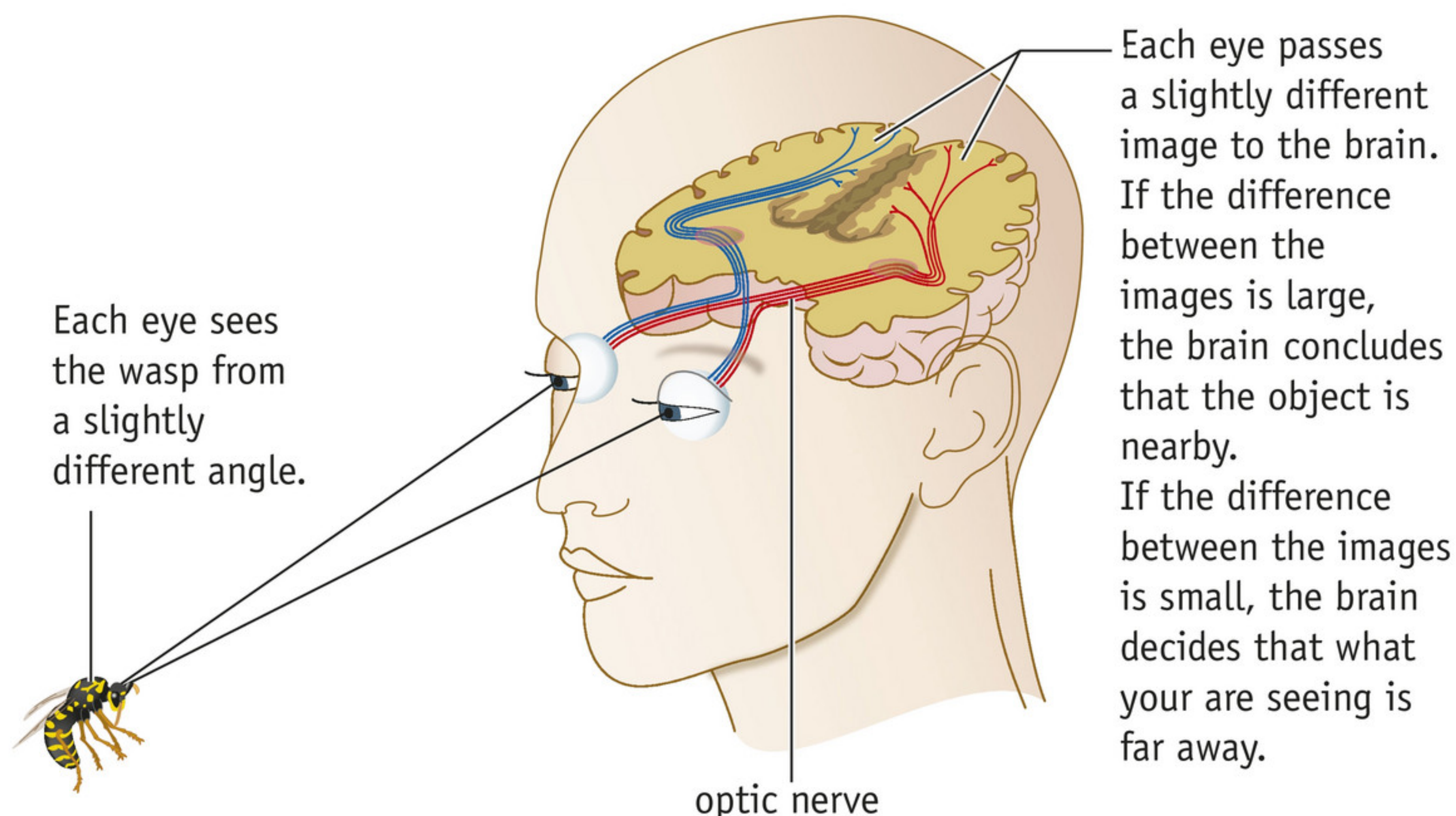


► **Fig. 78** Wedge paradox.



2 Seeing depth

▼ Fig. 79



Our eyes are about 6.5 cm apart (average distance between the pupils). This means that each eye sees the image that we are looking at from a slightly different angle (see figure 79). The images from both eyes are compared in the visual cortex of the cerebrum. The difference between the two images gives the brain information about the distance to the object. The larger the difference between the images from the two eyes, the closer something is. This makes it possible for you to estimate **depth** and distances. Figure 80 shows you how the sense of depth in 3D films works.

WB EXERCISES 1 AND 2, PAGE 79

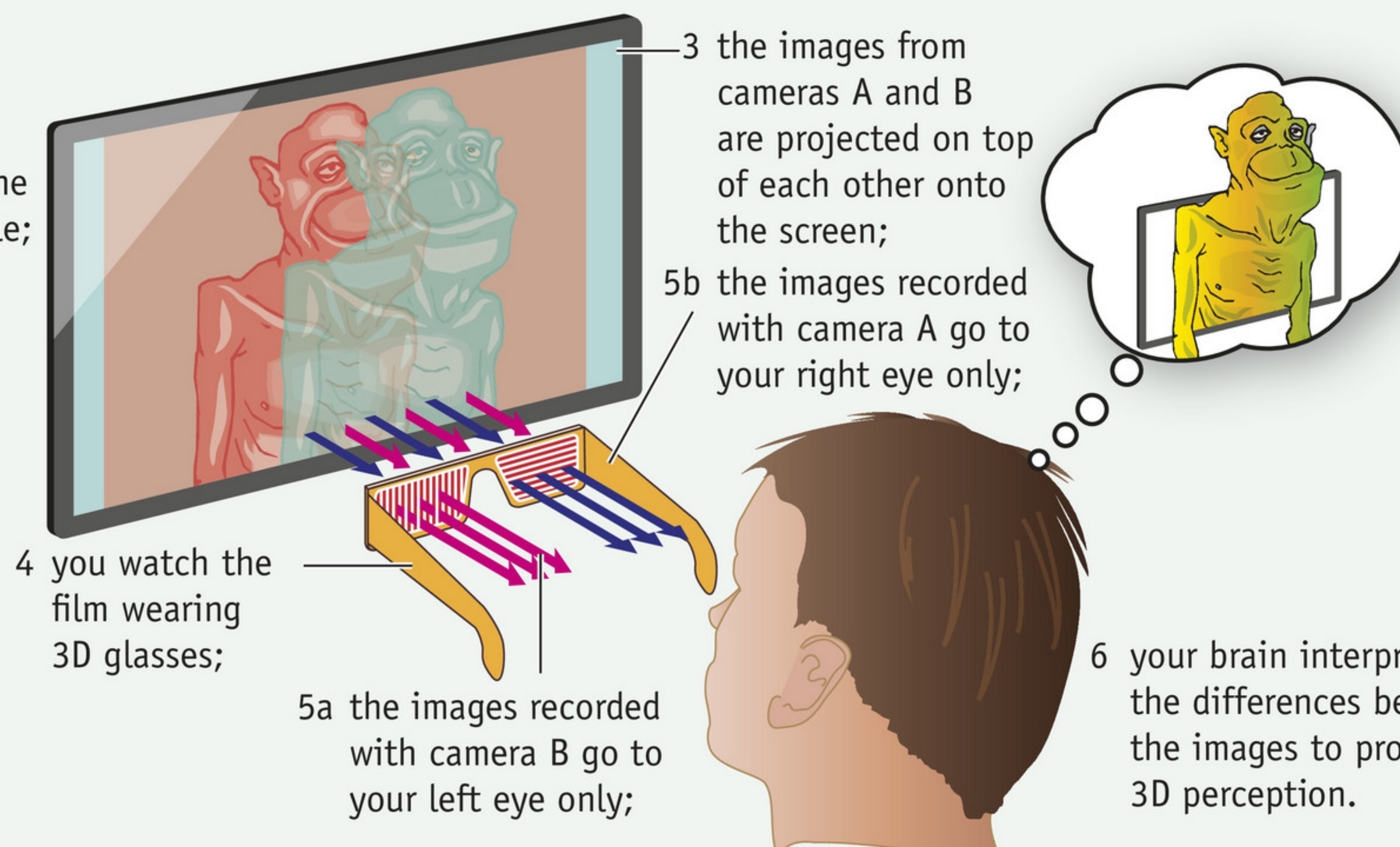
▼ Fig. 80

Watching 3D films

If you look at a normal picture, you do not see any depth. This is because photos are made with cameras that have only one lens. To make 3D films, you need two cameras and two lenses. Each camera records the film from a slightly different angle. At the cinema, the images from the two cameras are projected on top of each other (see the figure).

You need special 3D glasses to watch most the 3D films. 3D glasses separate the images from the two cameras so that each eye sees a different picture. Your brain turns the difference between the images into a 3D picture. 3D glasses can work in different ways. There is 3D TV as well now. That works in roughly the same way.

- 1 The 3D film is recorded using two cameras A and B that are fixed together;
- 2 each camera records the scene from a slightly different angle;

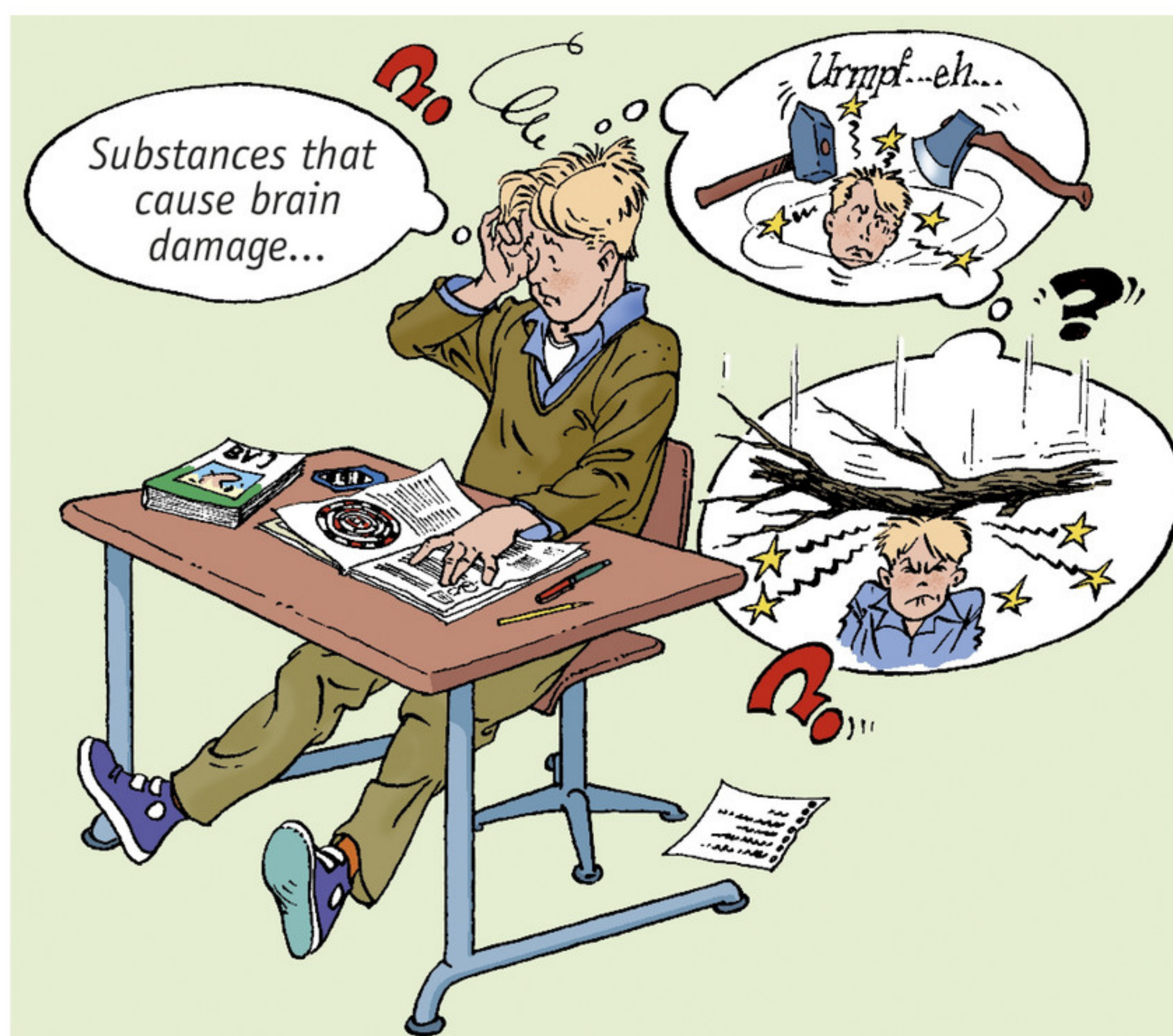


3 Spiral puzzle

In the basics, you learned a lot of new terms. You will find the descriptions of a number of these terms in your workbook. You are going to fill in the answers into a spiral puzzle.

WB EXERCISE 1, PAGE 80

▼ Fig. 81



7

Flowers, fruits and seeds



BASICS

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3	Compound flowers	139



This unit is called 'Flowers, fruits and seeds'. Flowers, fruits and seeds are parts of plants. You are going to be studying those parts in this unit.

Flowers, fruits and seeds all play a part in plant reproduction. Fruits and seeds can be produced from flowers. In this unit, you will learn how this happens and how fruits and seeds are dispersed.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 Flowers

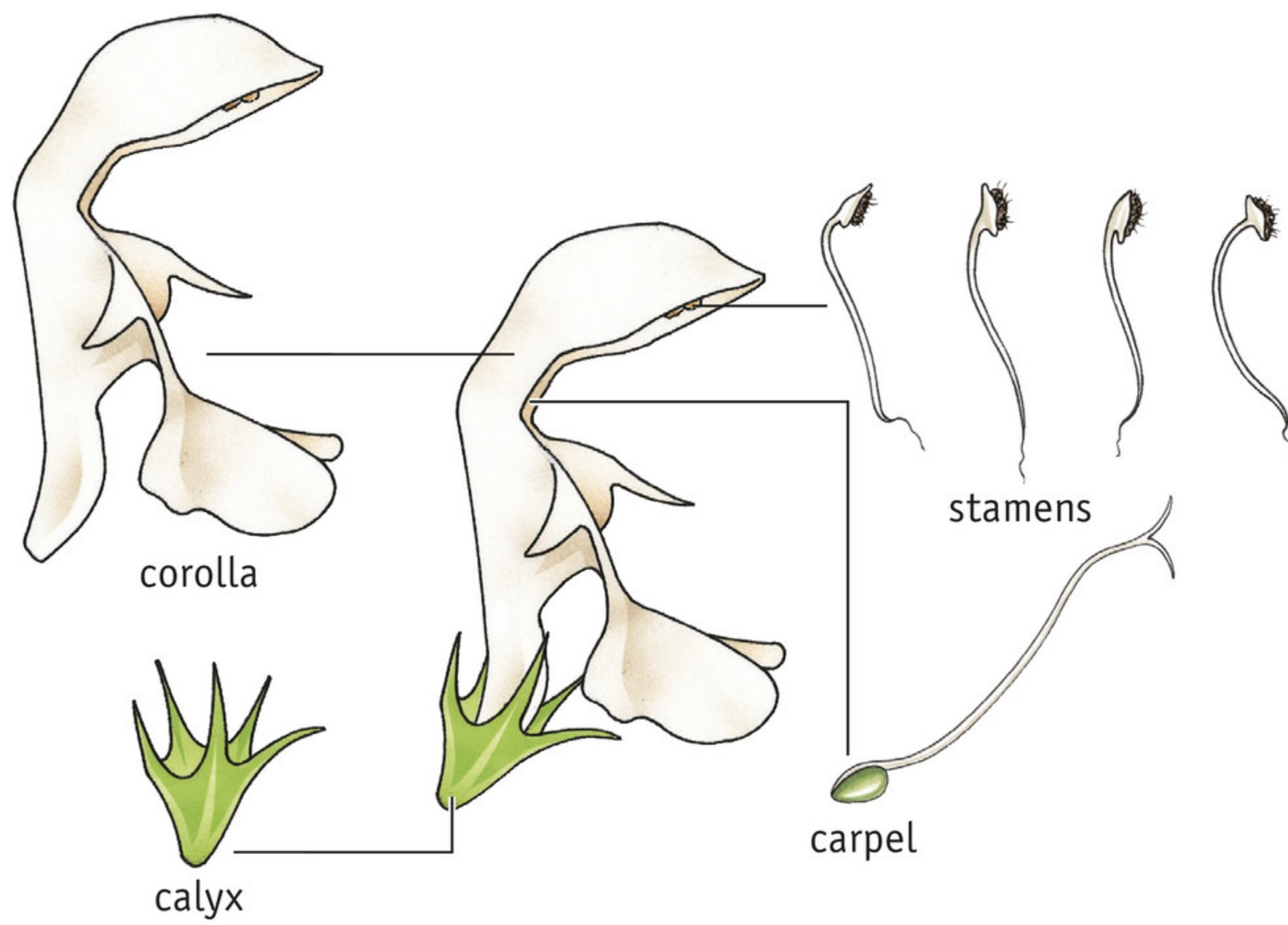
Huge numbers of flowers are grown and sold in the Netherlands. You may come across them anywhere in the world. The world's largest flower auction is in the Netherlands and we also enjoy putting on flower parades to show off how beautiful Dutch flowers are (see figure 1). Flowers are plant organs. Their function is reproduction. Flowers in nature are often smaller and less colourful than cultivated flowers.

▼ Fig. 1

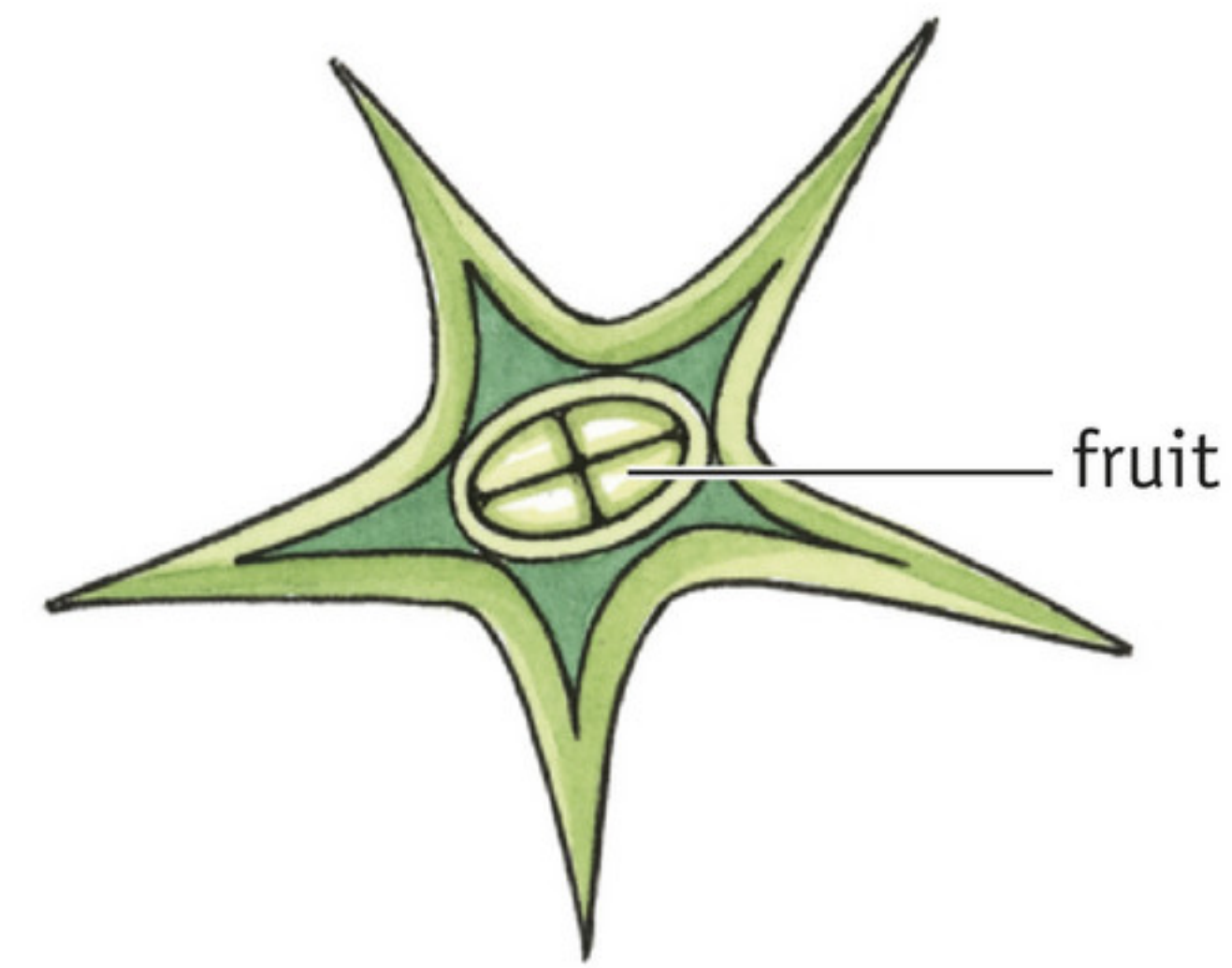


White deadnettles can often be seen growing along dykes and roadsides. They look rather like stinging nettles, but deadnettles do not sting. The flower of a white deadnettle consists of a green part and a white part. The green part is called the **calyx** and the white part is the **corolla**. The flower contains the reproductive organs: the **stamens** and the **carpels** (see figure 2). Once a white deadnettle has finished flowering, four small fruits can be seen in the calyx (see figure 3).

▼ **Fig. 2** Parts of a white deadnettle flower.



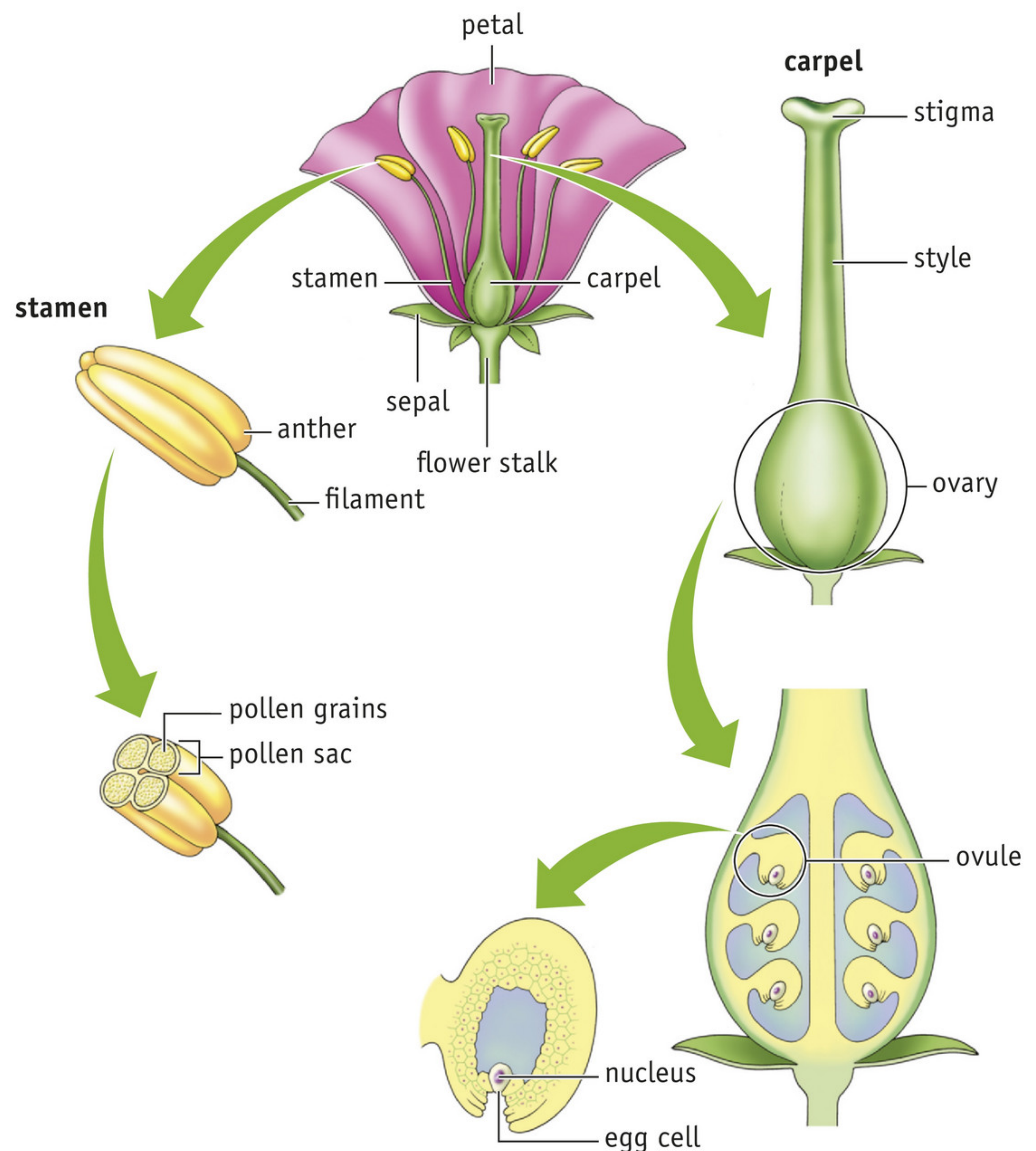
▼ **Fig. 3** Calyx with fruit.



THE STRUCTURE AND FUNCTION OF FLOWERS

Flowers can look very different, but most flowers have roughly the same structure.

► **Fig. 4** The structure of a flower.



▼ **Fig. 5** Brightly coloured petals (wild pansy).



▼ **Fig. 6** Grass flowers.



The **calyx** consists of **sepals**. These are generally green. In some plants, the sepals have grown together. They are then said to be **fused**. In other plants, the sepals are separate from one another. While the flower is still a bud, the calyx protects the rest of the flower against dehydration and cold. When the flower opens, the sepals fall off straight away in some flowers. In other flowers, the sepals remain attached for longer.

The **corolla** is made up of **petals**. In many plants, the petals are large and brightly coloured (see figure 5). This is so that they can attract insects. In other plants, such as grasses, the petals are small and green. You hardly notice that these plants have flowers at all (see figure 6). Just like the sepals, the petals may also be fused or separate.

Stamens are the male sex organs of a plant. A stamen is made up of a **filament** and an **anther** (see figure 4). The anther consists of **pollen sacs**. The pollen sacs produce **pollen**. Pollen is a powder that is made up of very small particles called **pollen grains**. Pollen grains are the male sex cells of a plant.

When the pollen sacs open, pollen grains are released. Mature pollen grains have a tough wall that protects them against dehydration, for example.

Carpels are the female sex organs of a plant. In many plant species, the flowers have just a single carpel. In other plant species, the flowers may have several carpels.

A carpel consists of a **stigma**, a **style** and an **ovary** (see figure 4). There are also carpels with several stigmas, and there are carpels without styles or carpels with several styles.

The ovary contains one or more **ovules**. Each ovule produces a single **egg cell**. An egg cell is a female sex cell. There is a **nucleus** in each egg cell. Pollen grains have nuclei too.

The white deadnettle and many other flowers produce **nectar**. Nectar is a sweet juice that attracts insects. The bees collect nectar and use it to make **honey** for their offspring (the larvae).

A lot of people like honey, so you can buy all kinds of products that have been made with honey (see figure 7).

WB EXERCISES 3 TO 6, PAGE 84

► **Fig. 7** Honey.



2 Pollination

While it is collecting nectar, a bee often gets covered in pollen (see figure 8.1). When the bee then flies to another flower, it takes the pollen with it. Hummingbirds live off nectar as well. They can suck nectar out of the flowers through their thin beaks (see figure 8.2). Pollen then ends up on their beaks. Hummingbirds visit hundreds of flowers of the same species on the same day and so play a role in dispersing the pollen. There are also bats that pollinate flowers (see figure 8.3).

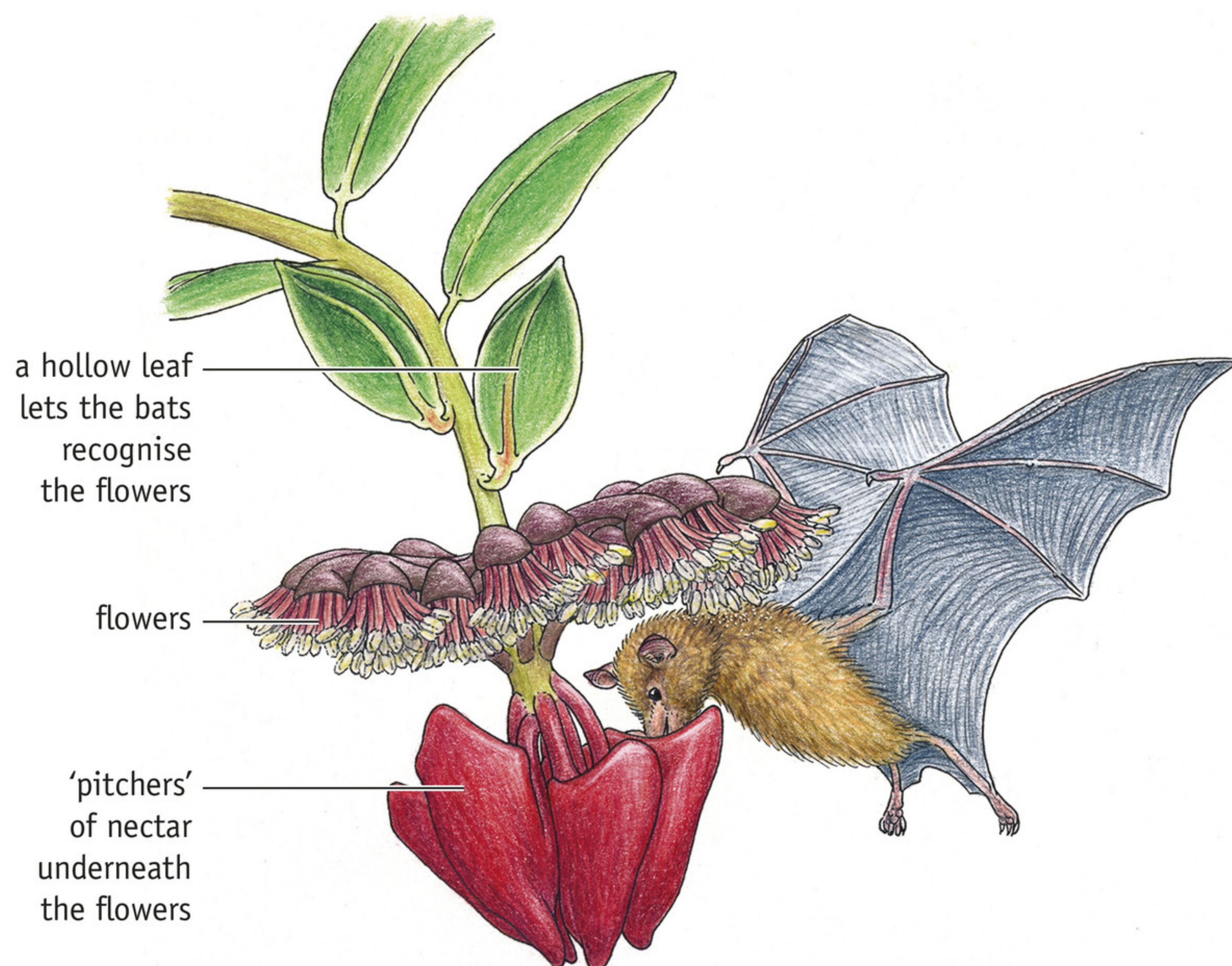
▼ Fig. 8



1 a bee covered in pollen

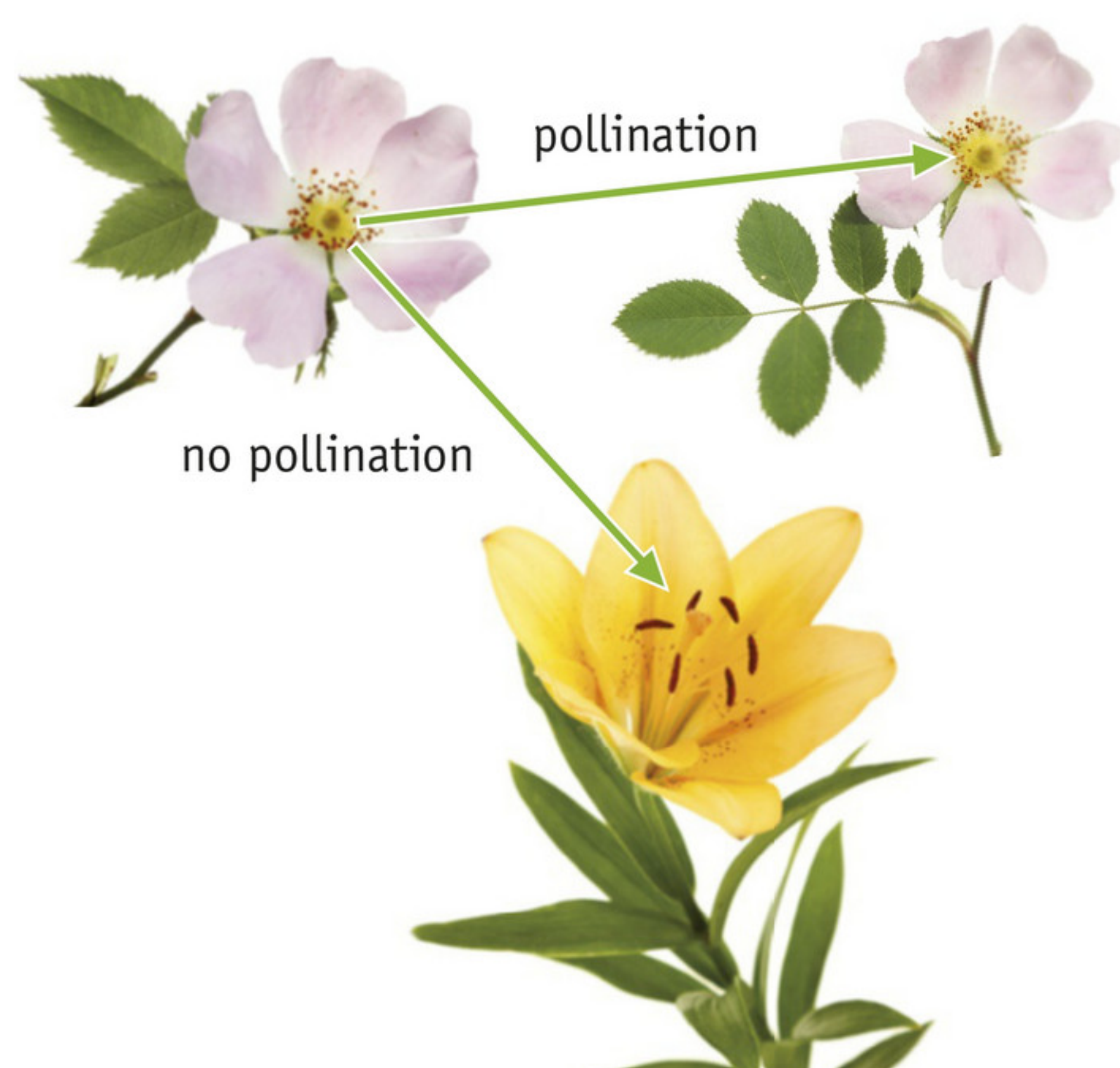


2 a hummingbird sucking nectar from a flower



3 a bat that pollinate flowers

▼ Fig. 9 Pollination or not?



Transferring pollen from a stamen to the stigma of a carpel is called **pollination**. But the pollen grains must get onto the stigma of a flower of the same plant species. If pollen ends up on the stigma of a flower of a different plant species, then we do *not* refer to that as pollination (see figure 9).

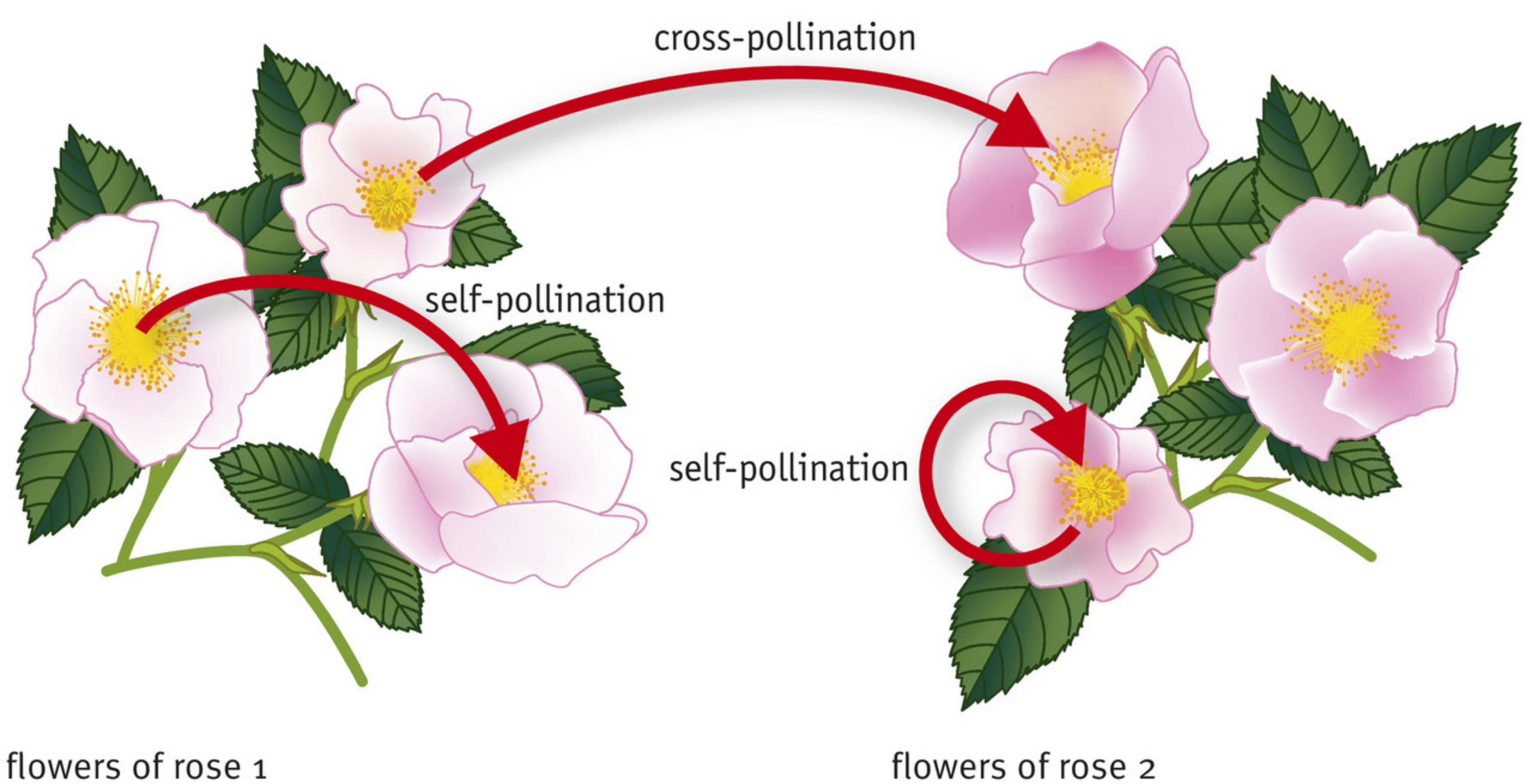
▼ **Fig. 10** Rosebushes have lots of flowers.



Many flowers have both stamens and carpels. Pollen from the stamens can get onto the stigma of the carpel of the same flower. This is called **self-pollination**. Some plants have more than one flower. Trees and shrubs can in fact have very large numbers of flowers (see figure 10). Pollen from one flower can also get onto the stigma or stigmas of another flower on the same plant. This is also self-pollination. In some plants, the stamens and carpels do not ripen at the same time. This means that there is no self-pollination in these plants.

Pollen can also get onto the stigmas of flowers of a different plant (of the same species). This is then known as **cross-pollination** (see figure 11).

▼ **Fig. 11** Cross-pollination and self-pollination.



Flowers that are pollinated by insects are called **insect-pollinated flowers**. Insect-pollinated flowers generally have large and brightly coloured petals. These attract insects. Insects also respond to the scent and to the nectar. Flowers that are pollinated by the wind are called **wind-pollinated flowers**. Wind-pollinated flowers are often small and inconspicuously coloured (see figure 12). The petals are generally green.

► **Fig. 12** A stinging nettle has wind-pollinated flowers.

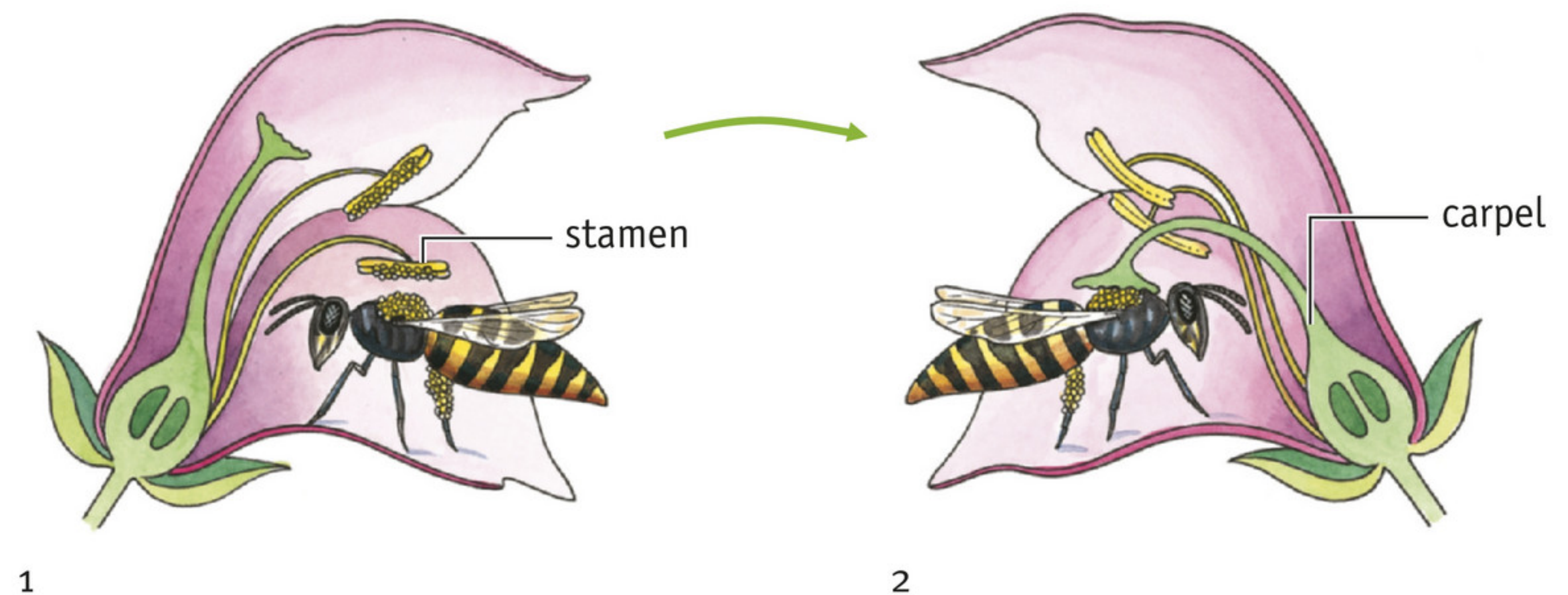


The pollen of insect-pollinated flowers is rough and sticky. The pollen then sticks easily to the bodies of insects (see figure 13).

When the insect then visits another flower to suck up more nectar, it will once again go past the stamens and stigmas. Pollen grains will then get stuck to the stigmas. A single insect can pollinate dozens of flowers this way. Bees are important pollinating insects, although many bees have died over recent years (see figure 14).

Many insects only visit the flowers of a single specific species, for example only white deadnettles. This means that there is a good chance that pollen will end up on the stigmas of a flower of the same species. Insect-pollinated flowers make relatively little pollen compared to wind-pollinated flowers.

► **Fig. 13** Pollination by an insect.



▼ **Fig. 14**

Bees in decline

Bees spend the winter as a swarm in a beehive. After the winter, there will always be a few hives in which the whole swarm of bees has died. That is not a problem, because new queens will be born in the spring and new swarms will appear. However, more and more swarms of bees have been dying over recent years. This has been happening not only in beekeepers' hives but also in nature. Not enough new bee swarms are appearing, and so there are fewer and fewer bees. A great deal of research is being done to prevent bees dying out. Scientists think that there are three causes:

- The number of different species of flowers in nature is decreasing, meaning that bees often eat the same food all the time. This makes them more likely to become sick and die.
- The use of pesticides (toxins) in gardens and in horticulture and agriculture means that bees are less strong when the winter starts.
- A small arachnid called the varroa mite weakens bees and transmits diseases.

The decline in bee numbers is a major problem. Plants such as beans, apples and tomatoes need bees for pollination. Without pollination, there will be no fruits and seeds. This will mean less food for humans.



In wind-pollinated flowers, the wind blows the pollen away from the stamens (see figure 15). The pollen may then end up on the stigma of a flower of the same plant species simply by chance. Because the chances of this happening are low, wind-pollinated flowers produce large numbers of pollen grains. The pollen grains are small and light so that they are readily carried in the air. The pollen grains of some species have small air bubbles so that they can float for a long time.

The anthers of wind-pollinated flowers often hang outside the flower to make it easy for the pollen to be blown away (see figure 15). The stigmas are large and feathery and generally protrude outside the flower. This increases the chance of pollination.

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▼ **Fig. 15** Pollination by the wind.



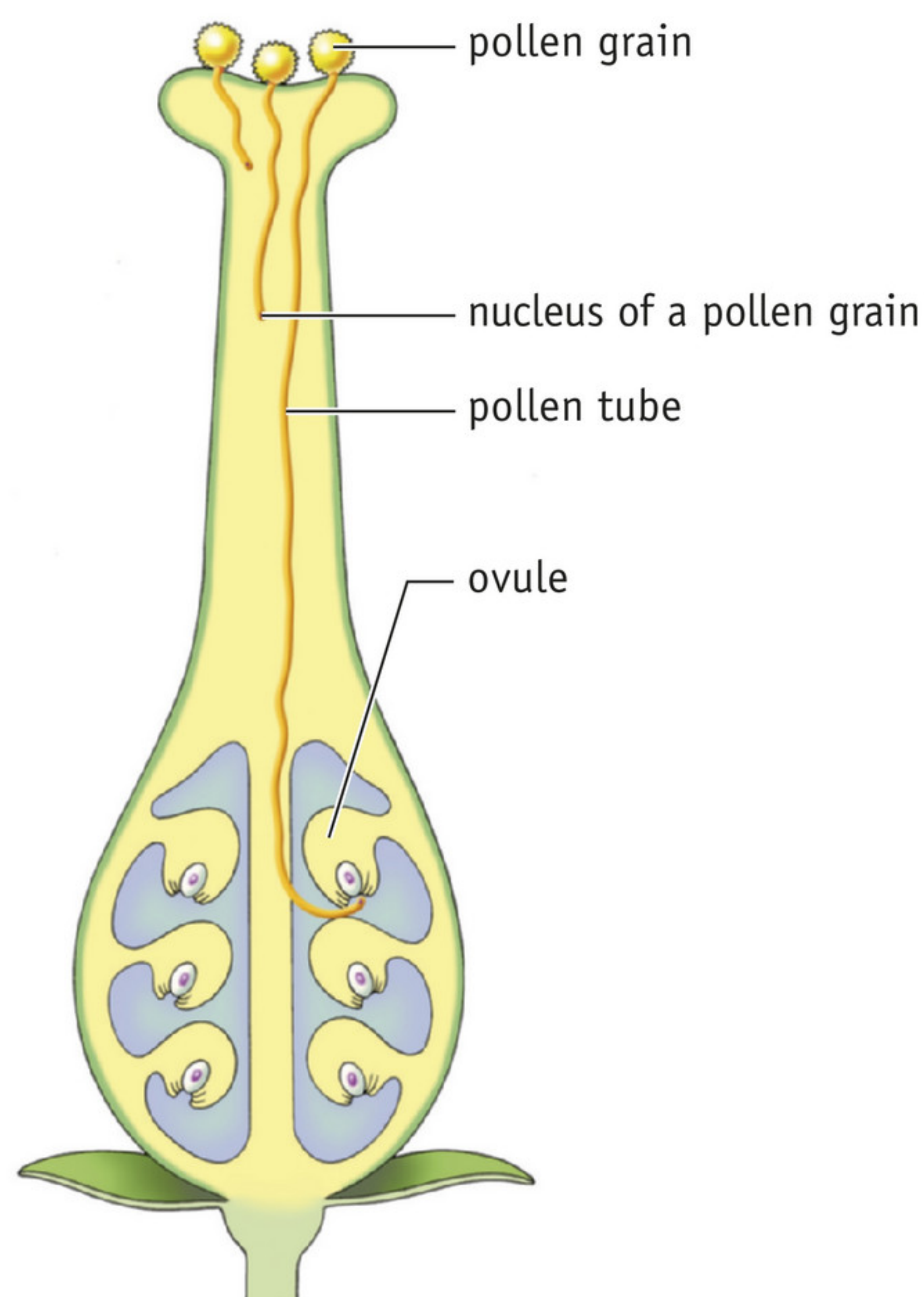
3 Fertilisation

When a pollen grain lands on the stigma of a plant of the same species, a tube starts to grow from it: a **pollen tube** (see figure 16). The pollen tube grows down the style to the ovule in the ovary (see figure 17.1). The nucleus of the pollen grain travels through the pollen tube to the ovule. On reaching the ovule, the tip of the pollen tube breaks open. The nucleus of the pollen grain penetrates the egg cell and fuses with the nucleus of the egg cell (see figure 17.2). This fusion of the nuclei of a male sex cell and a female sex cell is called **fertilisation**. Fertilisation produces a **fertilised egg cell**.

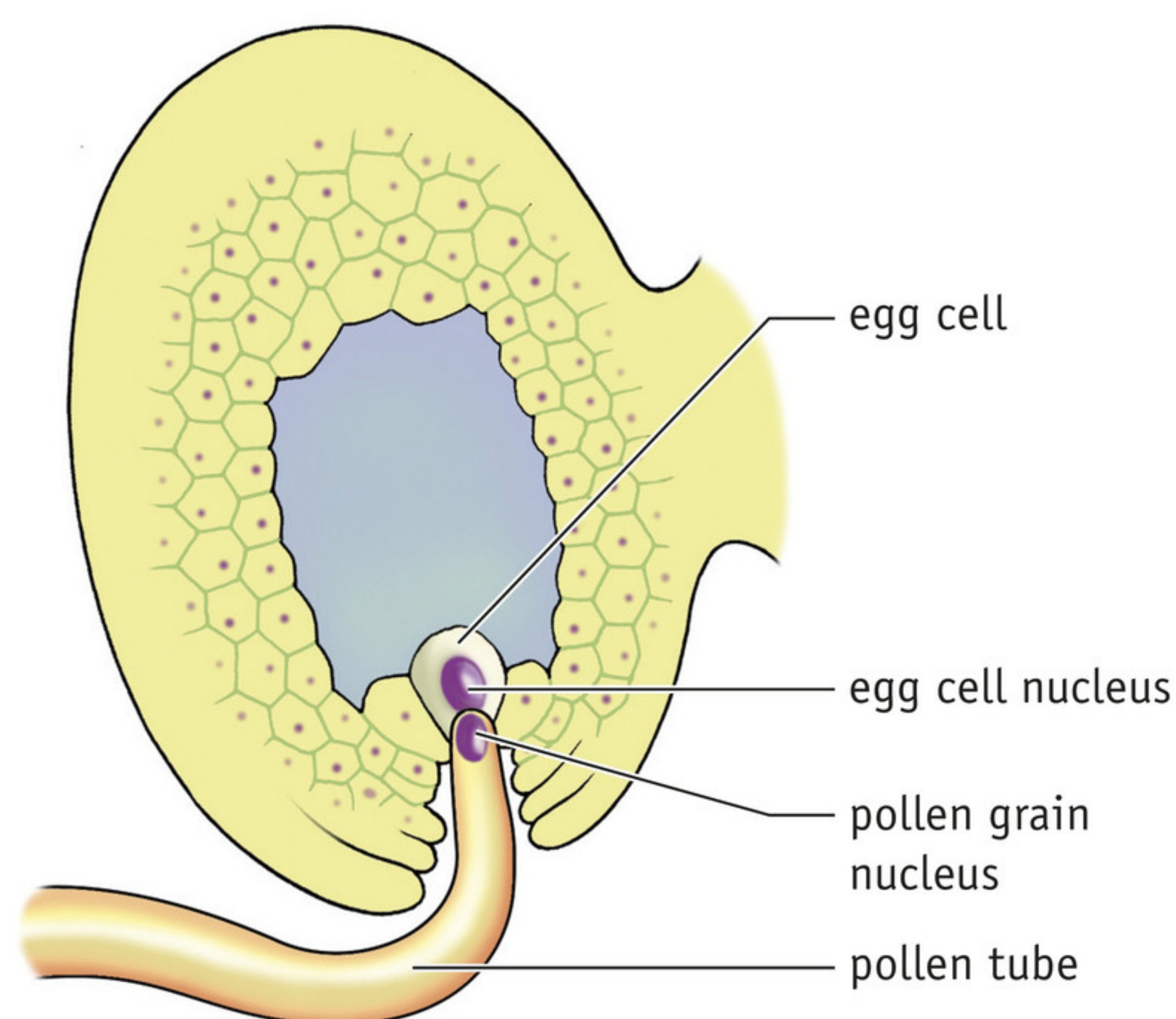
► **Fig. 16** Pollen grain with pollen tube.



▼ **Fig. 17** Fertilisation.



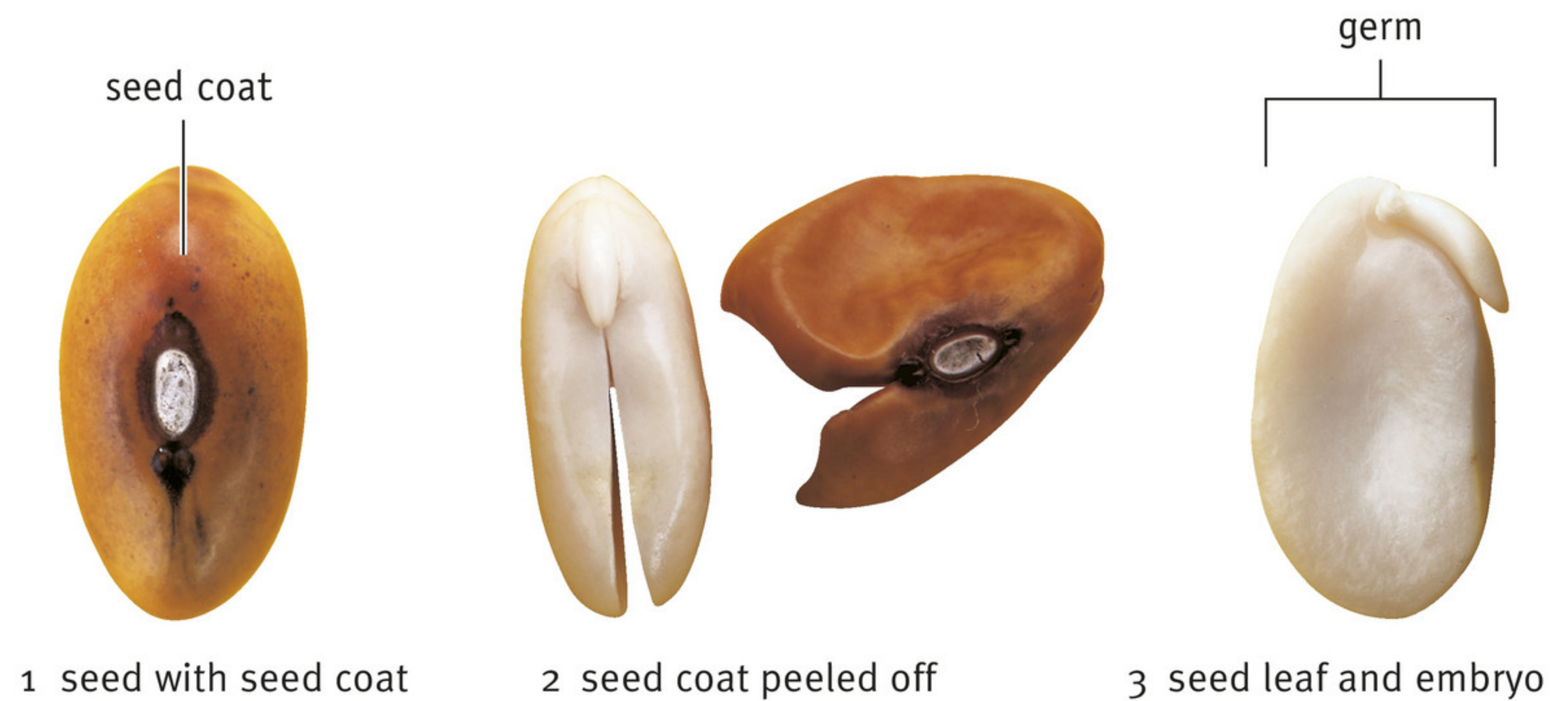
1 carpel with pollen tubes



2 ovule with part of the pollen tube

After fertilisation, the fertilised egg cell and the ovule start to grow. The ovule turns into a **seed**. Each seed contains a **germ** or **plant embryo** (see figure 18). In Unit 1 (What is biology?), you learned that germination of a seed is when the plant embryo grows into a seedling.

► **Fig. 18** Brown bean.



In figure 17, you can see that several pollen tubes can grow down the style at the same time. These pollen tubes will grow towards different ovules. The egg cell in each of these ovules can be fertilised. Every ovule with a fertilised egg cell can develop into a seed, so several seeds can form in a single ovary. If the egg cell in an ovule is not fertilised, that egg cell cannot grow to become an embryo. The ovule will then not grow to become a seed.

POLLINATION BY HUMANS

People have been trying to cultivate larger and more beautiful plants for a very long time. One way they do this is by pollinating the plants by hand. Someone who tries to develop plants with improved characteristics this way is called a plant breeder (see figure 19).

A plant breeder takes two plants of the same species but with different characteristics, for instance in terms of taste or size.

Pollen grains from one plant are then used to fertilise the egg cells of the other plant. To do this, the breeder uses a small brush to transfer pollen from one plant onto the stigmas of the other (see figure 20.1). This is called **crossing** them. The stigmas are then covered so that no other pollen can get onto them (see figure 20.2).

After crossing, seeds may be produced that will grow into plants that have exactly the characteristics that the breeder wanted.

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▼ Fig. 19

Tomato breeder

Hallo. My name is Ties and I work as a tomato breeder. We make use of breeding to try and improve the properties of the plants. Almost all the familiar crops that are grown were created by breeding. We look for wild plants with new characteristics. In 2012, a wild tomato plant was found that was not affected by whitefly. Whitefly is a species of insect that can do a great deal of damage in a greenhouse. A tomato variety that is not affected by whitefly will produce a better yield. I am crossing the wild tomato with tomato plants that we already cultivate in an effort to develop a variety that will produce nice tomatoes and is not affected by whitefly.

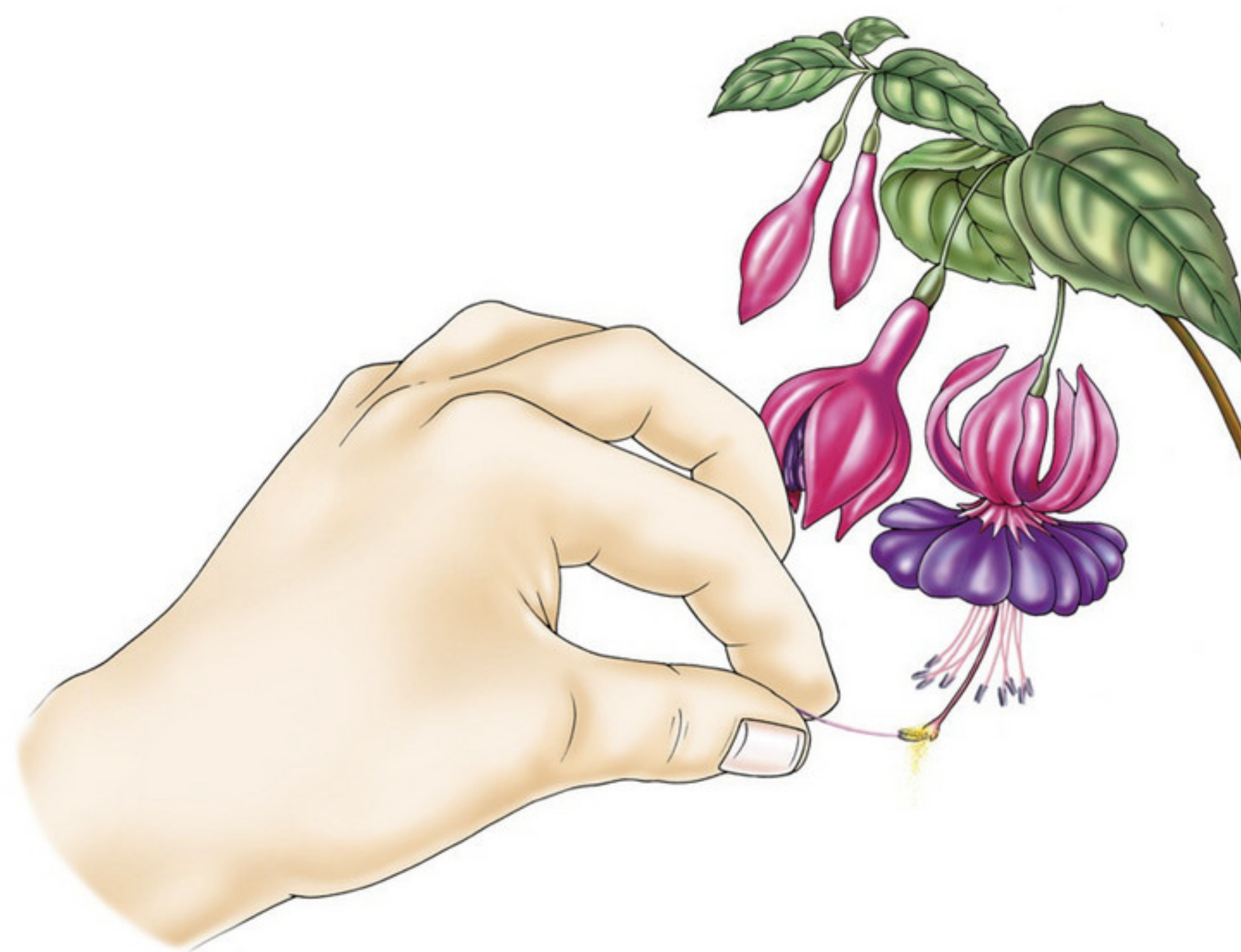


1 Ties at work



2 whitefly

► Fig. 20 Pollination by a plant breeder.



1 a breeder applies pollen to the stigma



2 the carpel is covered so that no other pollen can get onto the stigma

4 Fruits and seeds

A great deal changes in a flower after fertilisation. Figure 21 shows you some of these changes in the flower of a bean plant.

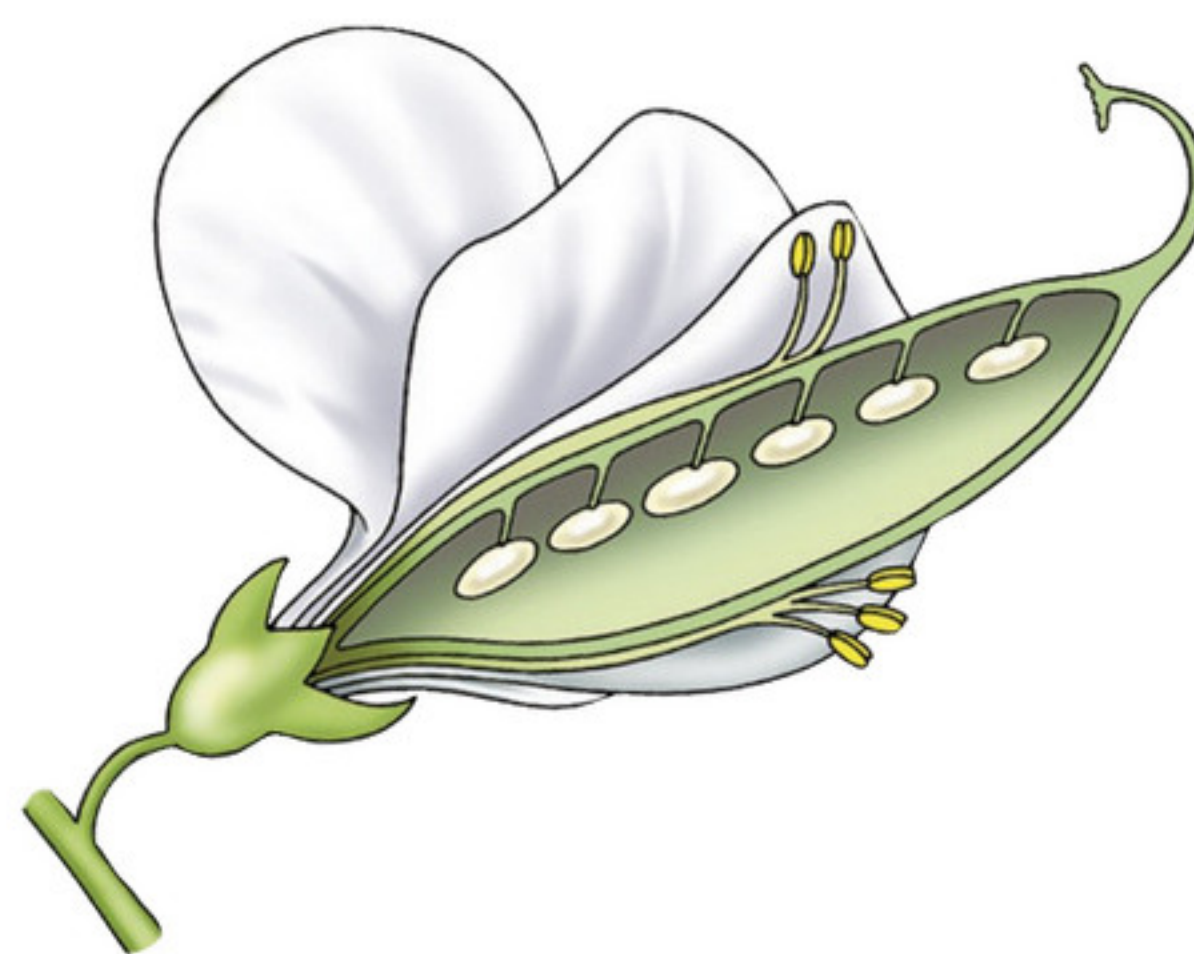
After fertilisation, one or more ovules in the ovary starts to grow. The egg cells in these ovules have been fertilised. The ovules develop into seeds (the beans). The other ovules in the ovary shrivel up. The ovary itself becomes bigger too. It grows into a long **fruit**: the French bean. This type of fruit is called a **pod**. The ovules in the flower of a French bean are in the ovary; the seeds of a French bean are in the fruit.

The flower of a French bean is on a stalk. The weight of the bean means that the fruit will hang down from the stalk. The petals and the stamens drop off. A remnant of the calyx remains at the stalk end. The remains of the style are at the other end of the French bean.

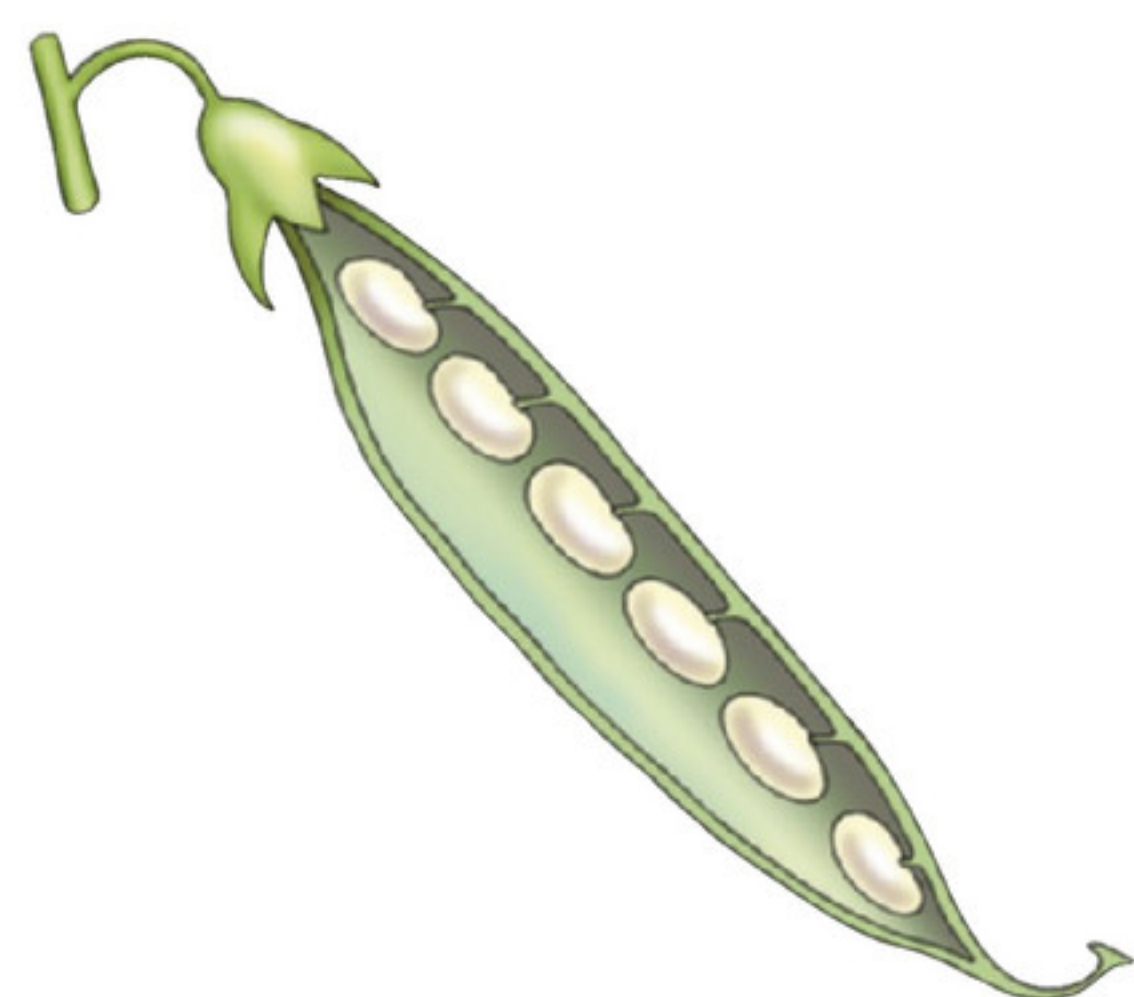
▼ **Fig. 21** Changes in the flower of bean plant after fertilisation.



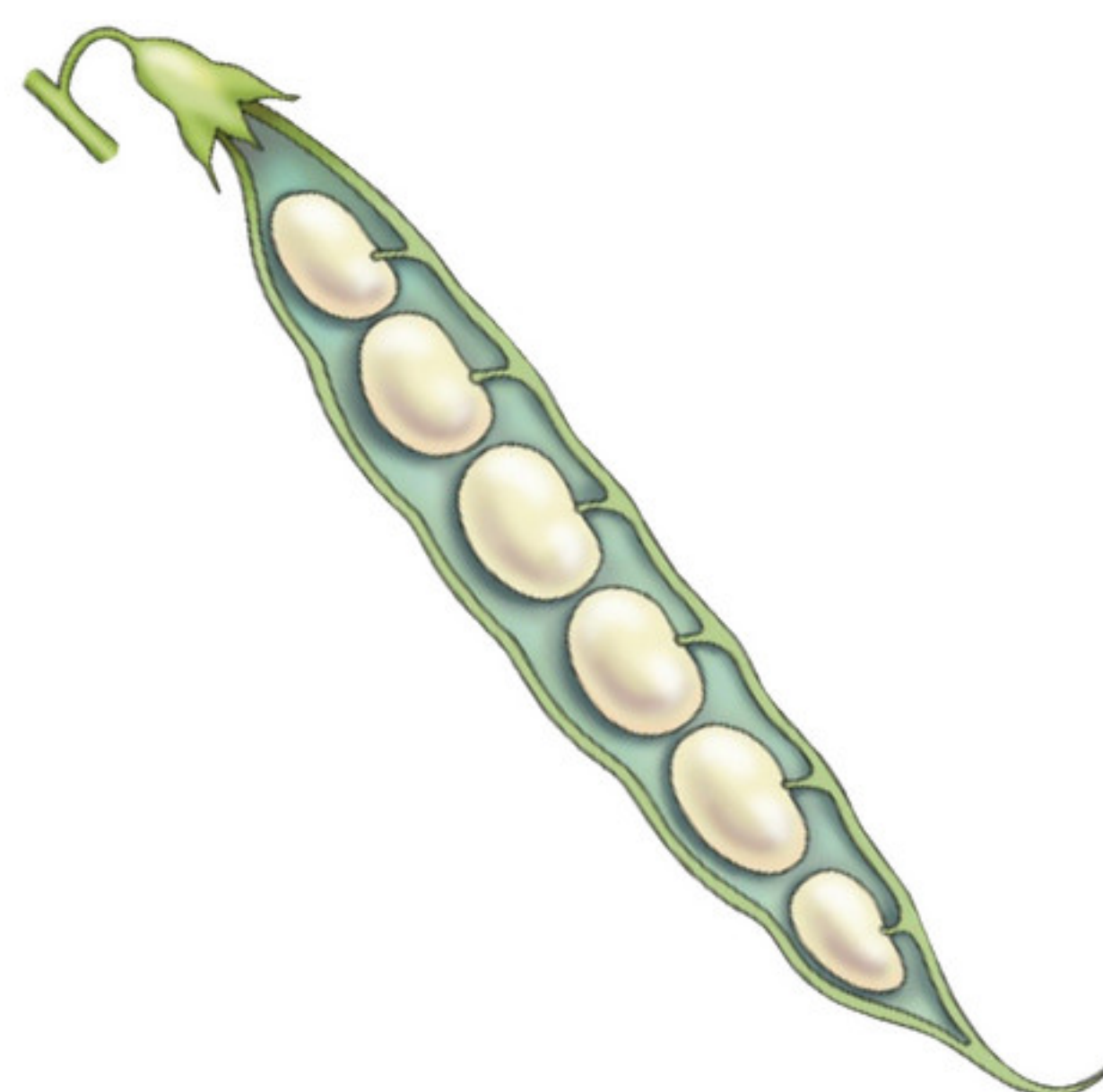
1 the flower before fertilisation



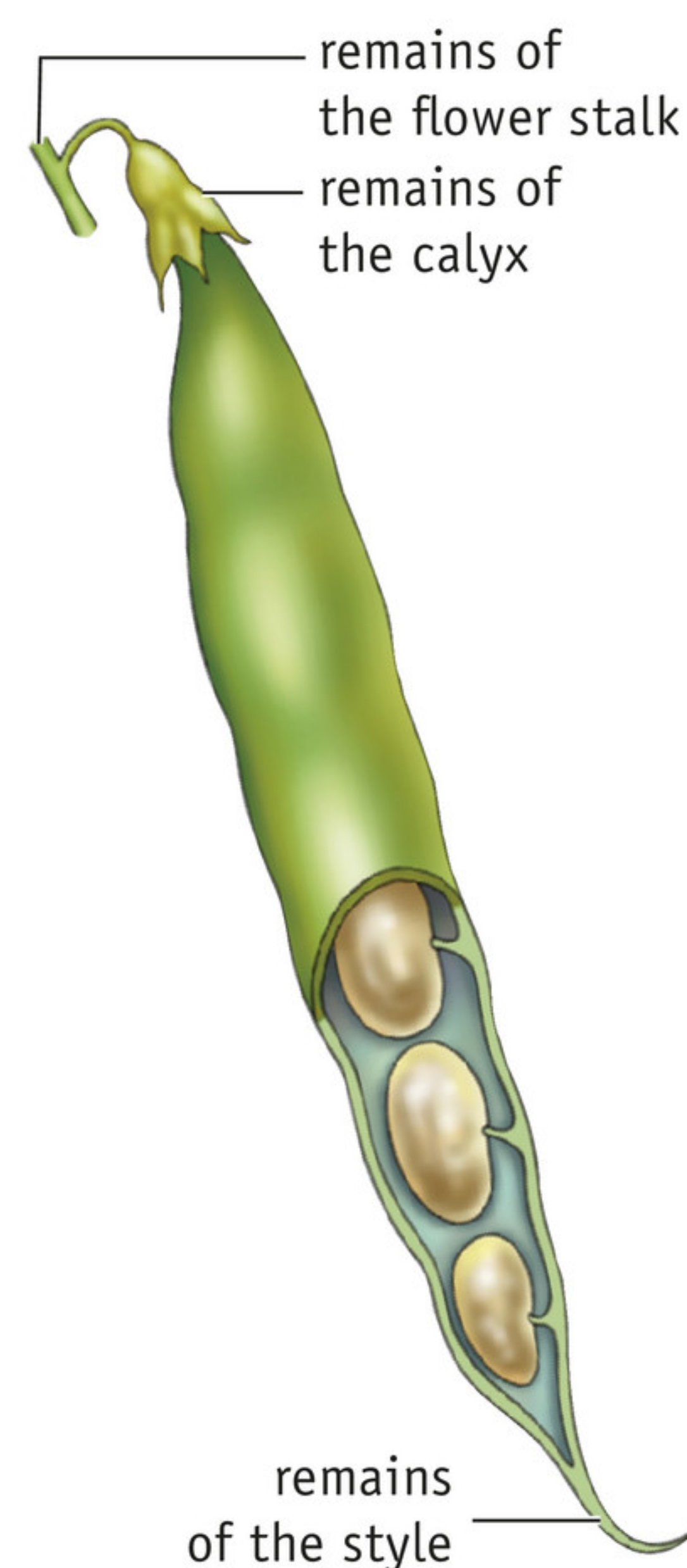
2 after fertilisation, the ovules and the ovary start to grow



3 the petals and stamens fall off; the ovary begins to lengthen



4 the calyx withers, leaving just dried sepals, and only a remnant of the style remains; the ovules become larger



5 when the bean is ripe, the seed coats become darker; eventually, the fruit bursts and the seeds are released

▼ Fig. 22

Some fruits contain fruit pulp: the soft and sometimes edible part of the fruit. In a banana or an orange, the fruit pulp develops from the ovary. Figure 22 shows you the development from flower to fruit in oranges, bananas and coffee beans.

How do oranges, bananas and coffee beans develop?

In oranges, bananas and coffee beans, the fruit's skin and pulp develop from the ovary. The seeds of oranges and coffee beans develop from the ovules. The illustrations show how this development progresses. You eat the pulp of the fruits of orange

trees and banana plants. You only drink a liquid made from the roasted and ground seeds of coffee plants (coffee beans). Coffee beans are the basis of coffee, an invigorating drink that contains caffeine.

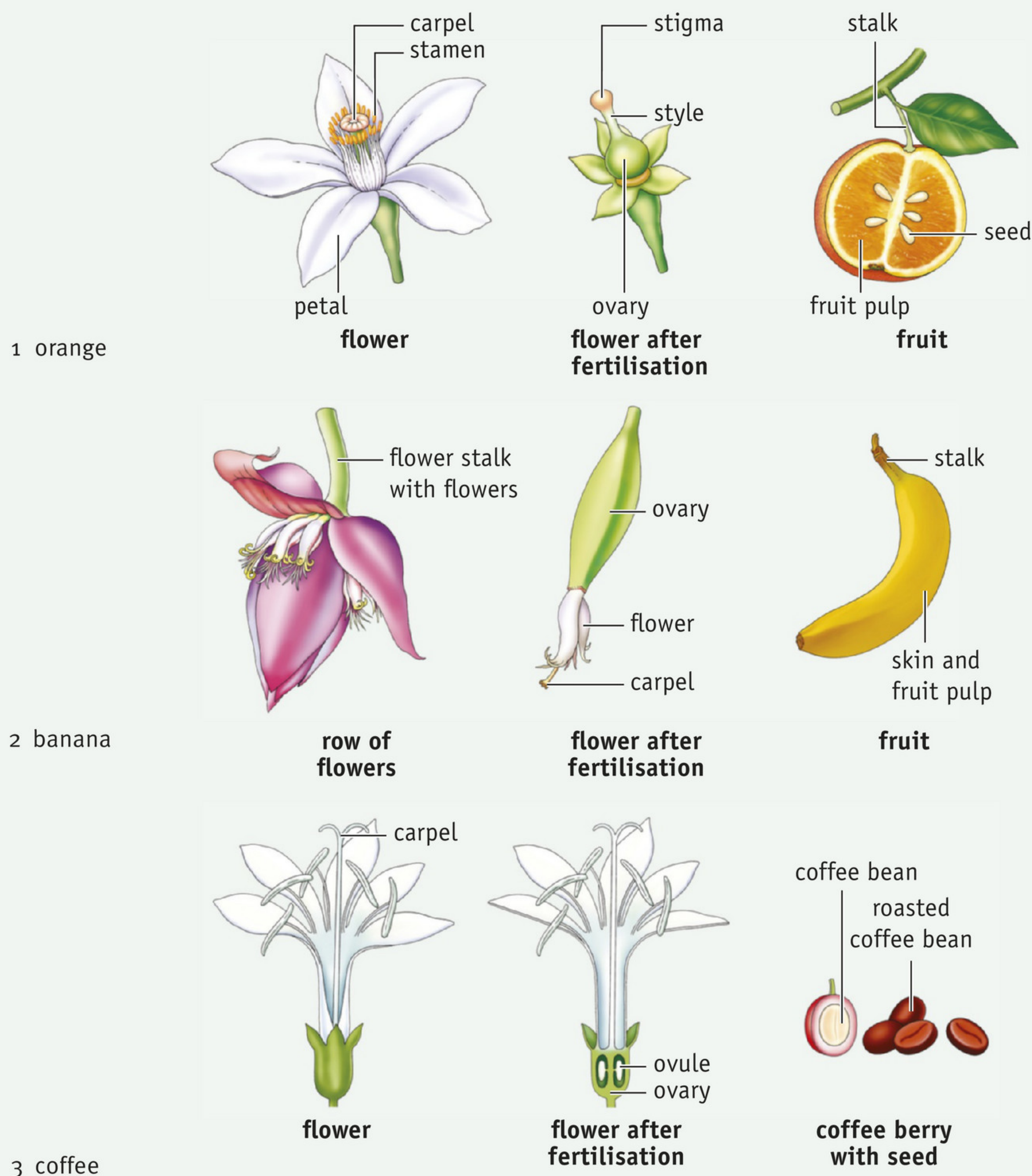
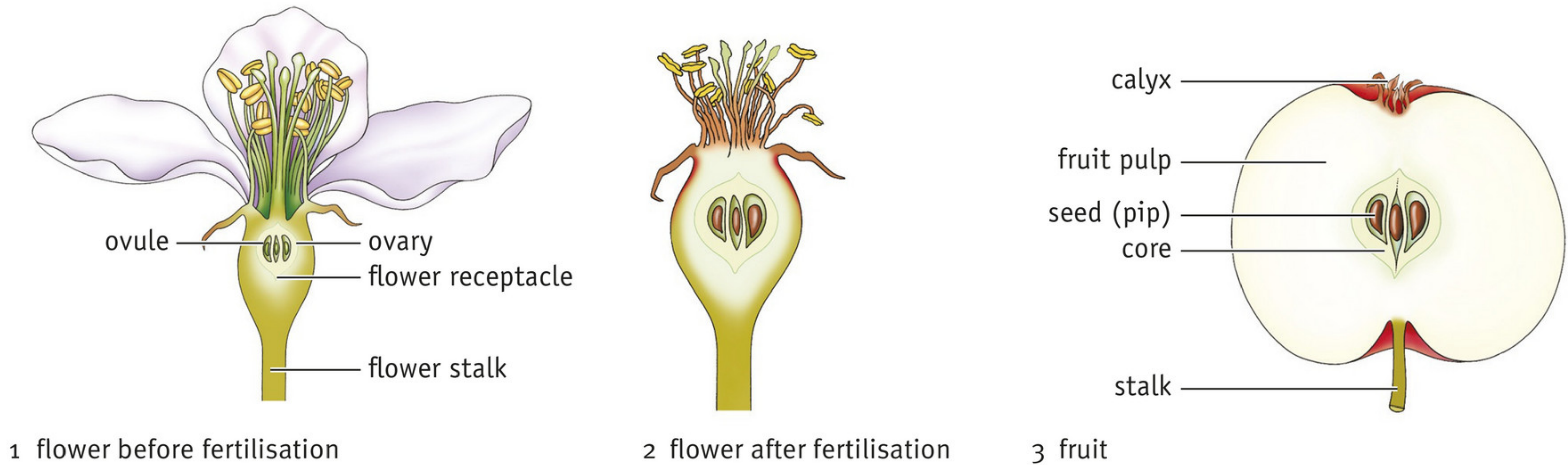


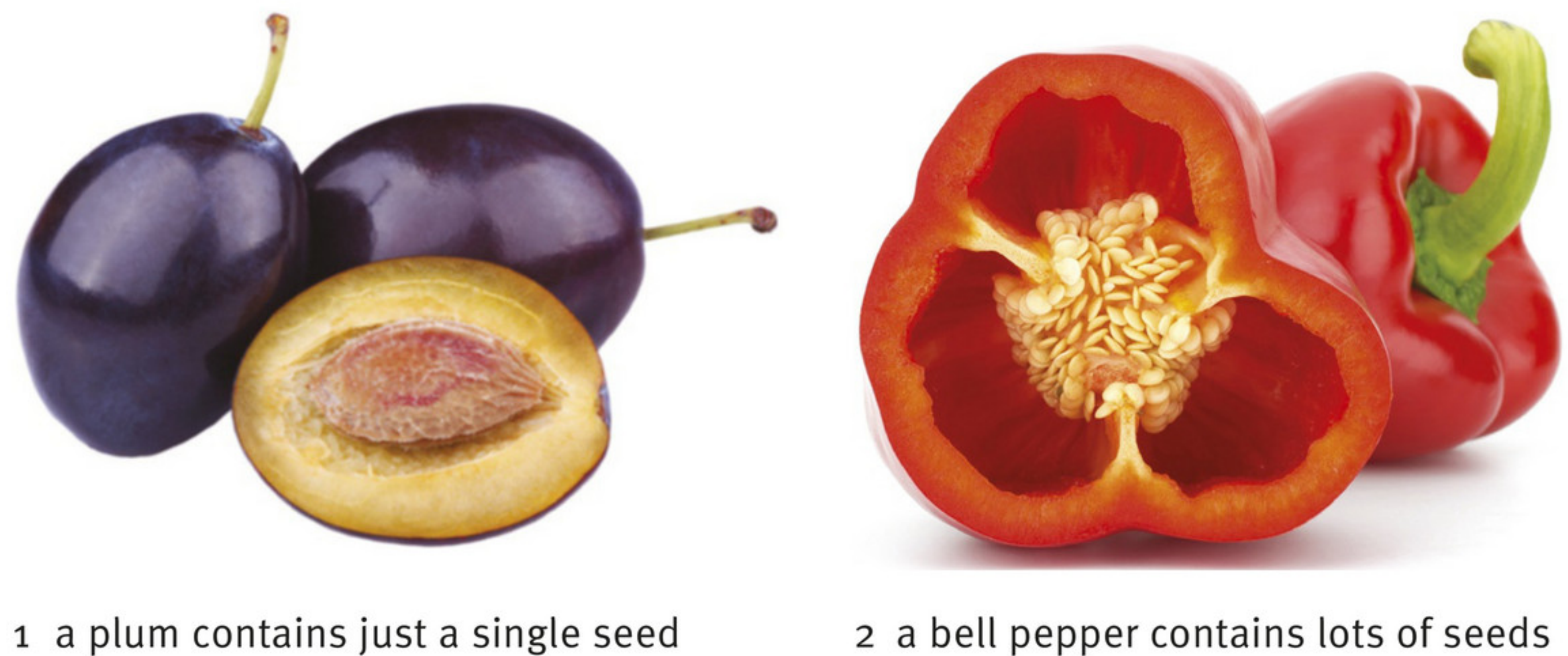
Figure 23 shows you the development from flower to fruit in an apple. In an apple, the fruit pulp comes from the **flower receptacle**. The ovary of an apple flower becomes the core of the apple. The core contains the apple seeds.

▼ **Fig. 23** Development from flower to fruit in an apple.



Apples, cherries, tomatoes and legumes are all fruits. Beans, peas, apple and tomato pips and cherry stones are all seeds. Some fruits contain a single seed; others fruits contain a large number (see figure 24). One melon can contain hundreds of seeds. Remember that each of these seeds requires the nucleus of an egg cell to have fused with the nucleus of a pollen grain!

▼ **Fig. 24** Seeds.



EDIBLE FRUITS AND SEEDS

You have learned that a seed contains reserves of food for the seedling that can grow from the embryo. This reserve food that is present in the seeds can also serve as food for animals and humans (see figure 25). The pulp of many fruits is also eaten by humans and animals (see figure 26).

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▼ **Fig. 25** Seeds you can eat.



▼ **Fig. 27**

▼ **Fig. 26** Fruits you can eat.



Fruit grower

Hallo. I'm Julie and I'm a fruit grower. On our family farm, we grow cherries, plums and apples. Most of our land is used for growing apples. The beehives are placed in the apple orchard in April so that the apple blossom (the apple flowers) will get pollinated. Pollination of the apple blossom is important for the fruit production. The apple harvest is much better when beehives are present than when they are not there.

We have experience with various apple varieties such as Jonagold, Red Delicious, Golden Delicious and Gloucester (see the illustration). We have sometime had poorer yields because of the bees in our beehives dying. Apple blossoms that have not been pollinated and not been fertilised do not generally develop into a fruit. But we did note that some apple varieties are less sensitive to declining bee numbers and still performed reasonably.



1 Jonagold

2 Red Delicious

3 Golden Delicious

4 Gloucester

5 Dispersal of fruits and seeds

Fruits containing seeds are produced from flowers. Each seed contains an embryo that can develop into a new plant. For the plants, it is helpful for the seeds to be spread over a large area. They do not then all end up in the same place, which allows more of them to germinate. Fruits are one way of ensuring that the seeds are dispersed. This can happen in a variety of ways.

DISPERSAL BY THE PLANT ITSELF

The fruits of some plants scatter the seeds themselves. The fruits of the cranesbill (see figure 28.1) burst open when they are ripe. This is done with enough force to eject the seeds quite a distance (see figure 28.2). Other examples of plants that disperse their seeds themselves are peas, beans, broom and balsam (see figure 29).

► **Fig. 28** Cranesbill.



1

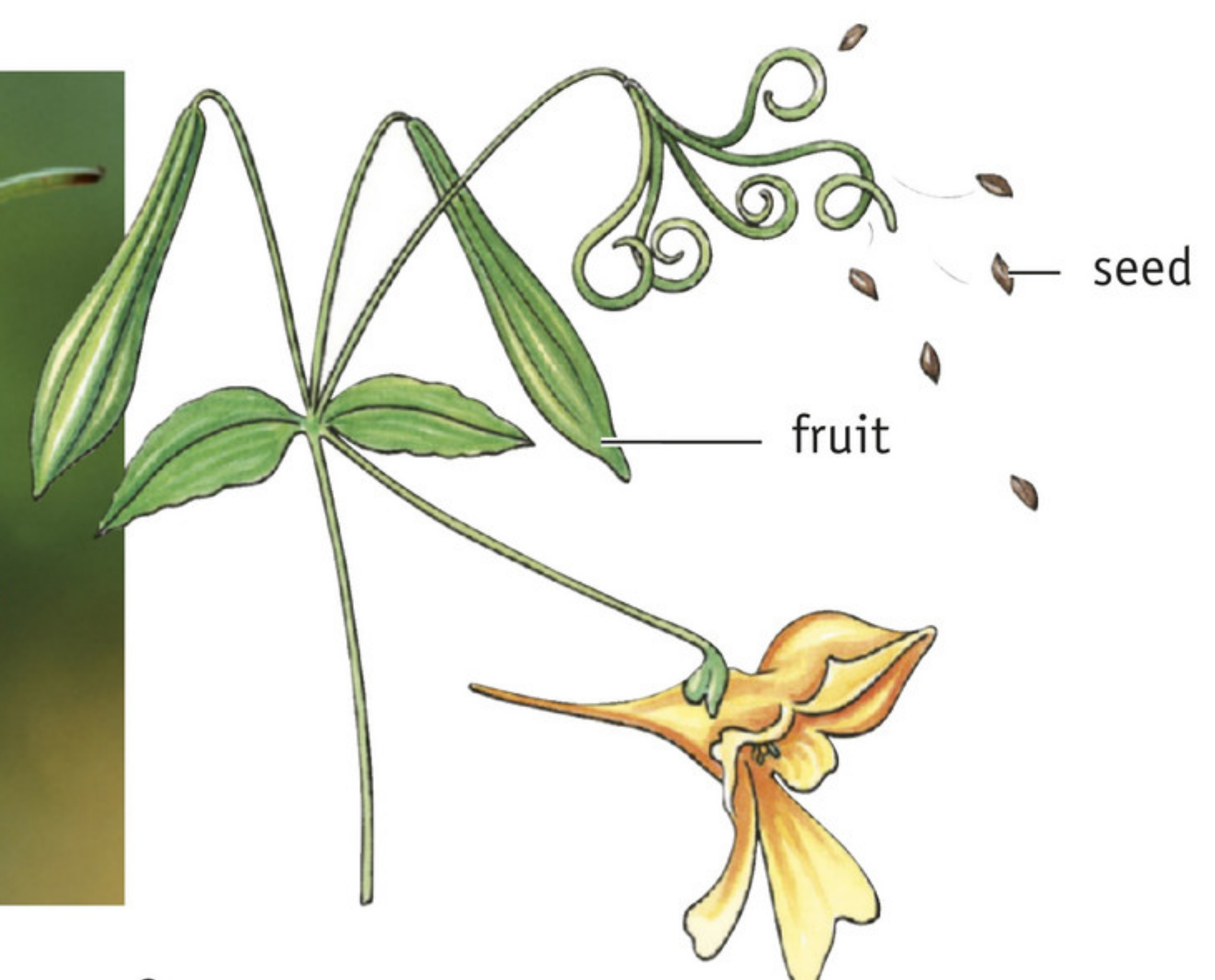


2 the fruit bursts open and ejects the seeds

► **Fig. 29** Touch-me-not balsam.



1



2

▼ Fig. 30 Dandelion.



1 flower



2 a dandelion that has finished flowering



3 the fruit of a dandelion

DISPERSAL BY THE WIND

In nature, many fruits and seeds are small and can be dispersed by the wind. These fruits and seeds often have features that let them float in the air for longer.

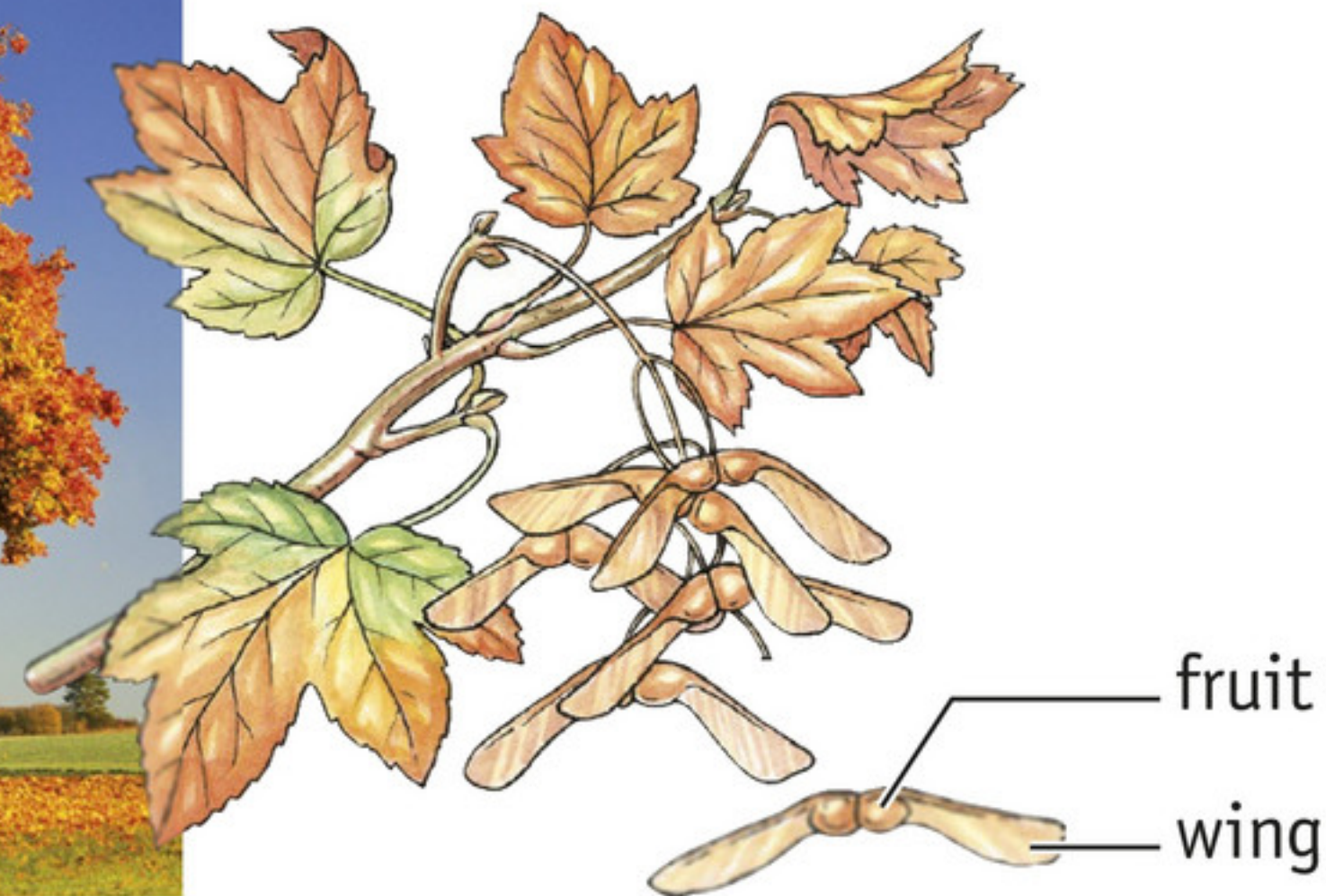
You have undoubtedly blown a dandelion clock at some point (see figure 30.2). What you are doing then is blowing away the fruits (containing the seeds) of the dandelion. The fruit surrounds the seed. This fruit has stayed very small and it does not contain any pulp. Each fruit has a plume of fluff that lets it stay floating in the air (see figure 30.3).

The fruits of the lime tree and the sycamore (see figure 31) have wings.

▼ Fig. 31 Sycamore.



1



2 the wind blows the winged fruits away

DISPERSAL BY ANIMALS

There are also plant species in which animals disperse the fruits and seeds. The fruits in many of these plant species have juicy pulp. Figure 32.1 shows the fruits (berries) of a rowan tree. Many birds like these berries (see figure 32.2). The fruits enter the birds' stomachs, where the fleshy part of the fruit is digested but not the seed. The seeds are then passed out in the bird's droppings. If conditions are favourable, the seeds may germinate where they fall.

▼ Fig. 32 Rowan.



1



2 birds eat berries and the seeds are passed out elsewhere

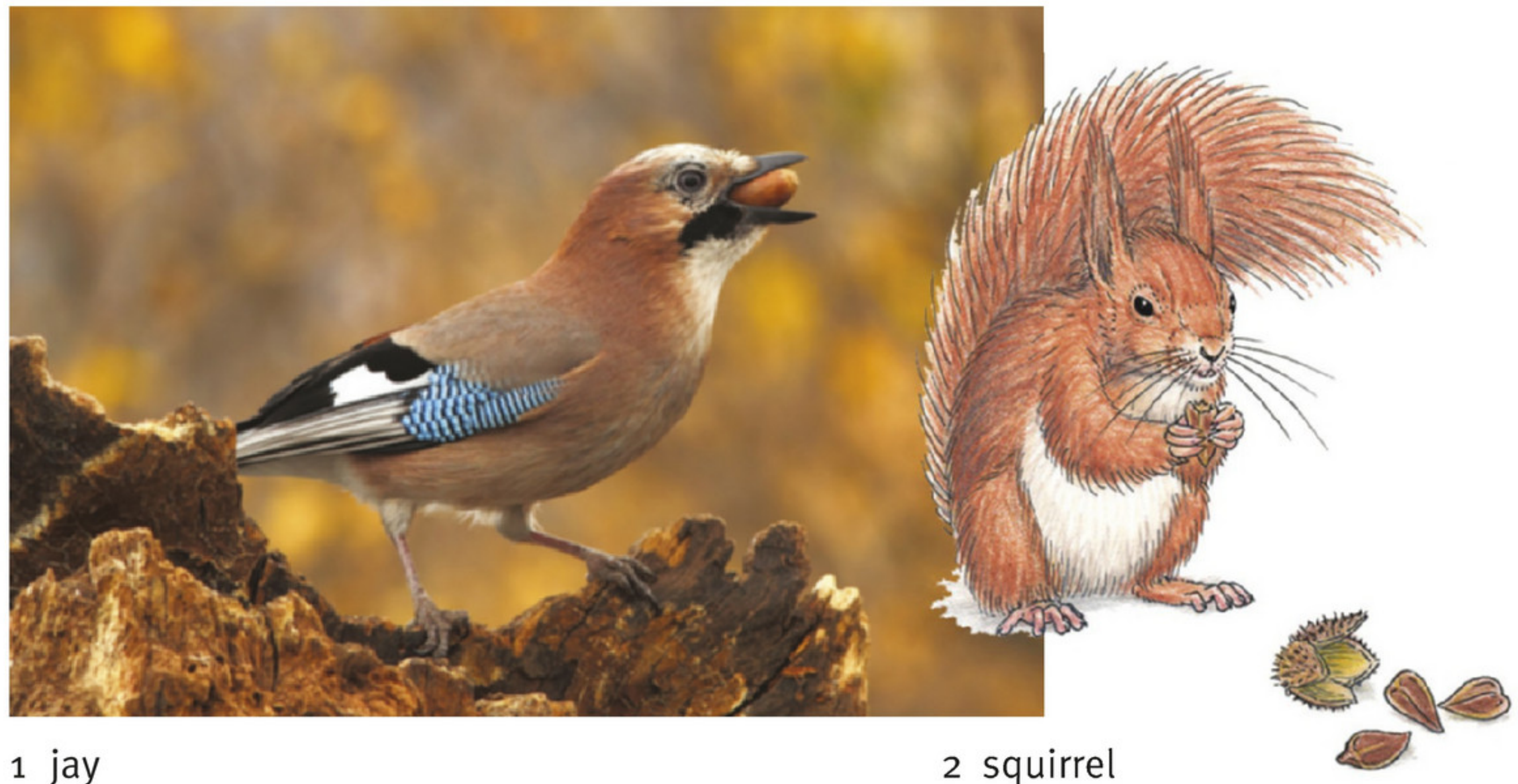
Squirrels gather acorns and beech nuts for their winter food stock (see figure 33). Not all the seeds are eaten, because an animal may sometimes not use all its stocks of food. The seeds have then been dispersed and may germinate.

Some plant species produce seeds that have small hooks on them. These fruits can easily stick onto the fur of passing animals. Later they fall off or are brushed off by the animal. Examples of this are the fruits (burrs) of burdock and burr marigolds (see figure 34).

People disperse seeds as well. This is often done accidentally, for instance when seeds stick in the ribs on the soles of your shoes. The seeds may then fall off again somewhere else.

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► **Fig. 33**



► **Fig. 34** Sticky burrs.



6 Asexual reproduction

You have learned that seed plants reproduce by making seeds. A seed develops from an ovule with a fertilised egg cell. When fertilisation is involved in reproduction, we call it **sexual reproduction**. In seed plants, sexual reproduction takes place when the nucleus of a pollen grain fuses with the nucleus of an egg cell.

Seed plants can also reproduce without fertilisation. In that case, part of the parent plant grows into a new plant. We call this **asexual reproduction**. You can see an example of this in figure 35. In this plant, small plantlets are growing at the edges of the leaves. When these plantlets fall off, each of them is capable of growing into a new plant.

▼ Fig. 35 Mother-of-Thousands.



▼ Fig. 36 Potato.



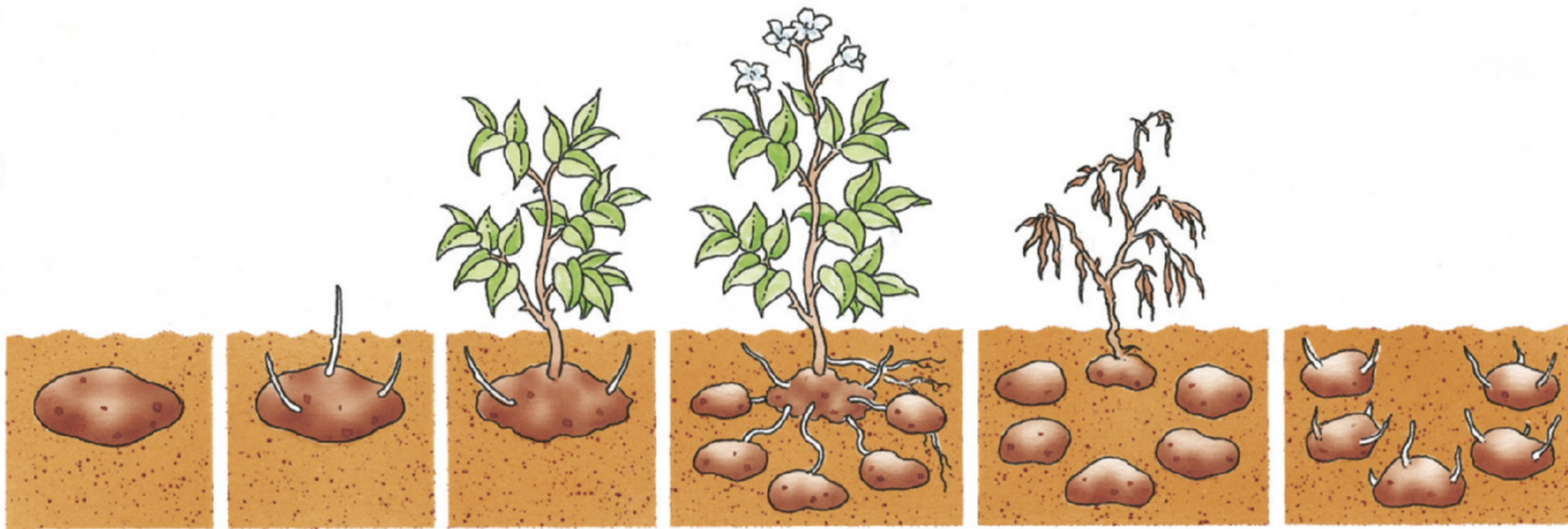
TUBERS

There are many different ways for asexual reproduction to take place. In potato plants, asexual reproduction takes place through **tubers**. You learned in Unit 2 (Plants) that in the autumn many plants store reserves of food in their roots. Other plants store reserves of food in the bottom part of the stem, which is below the ground. When the stem has become thicker like that, we call it a tuber.

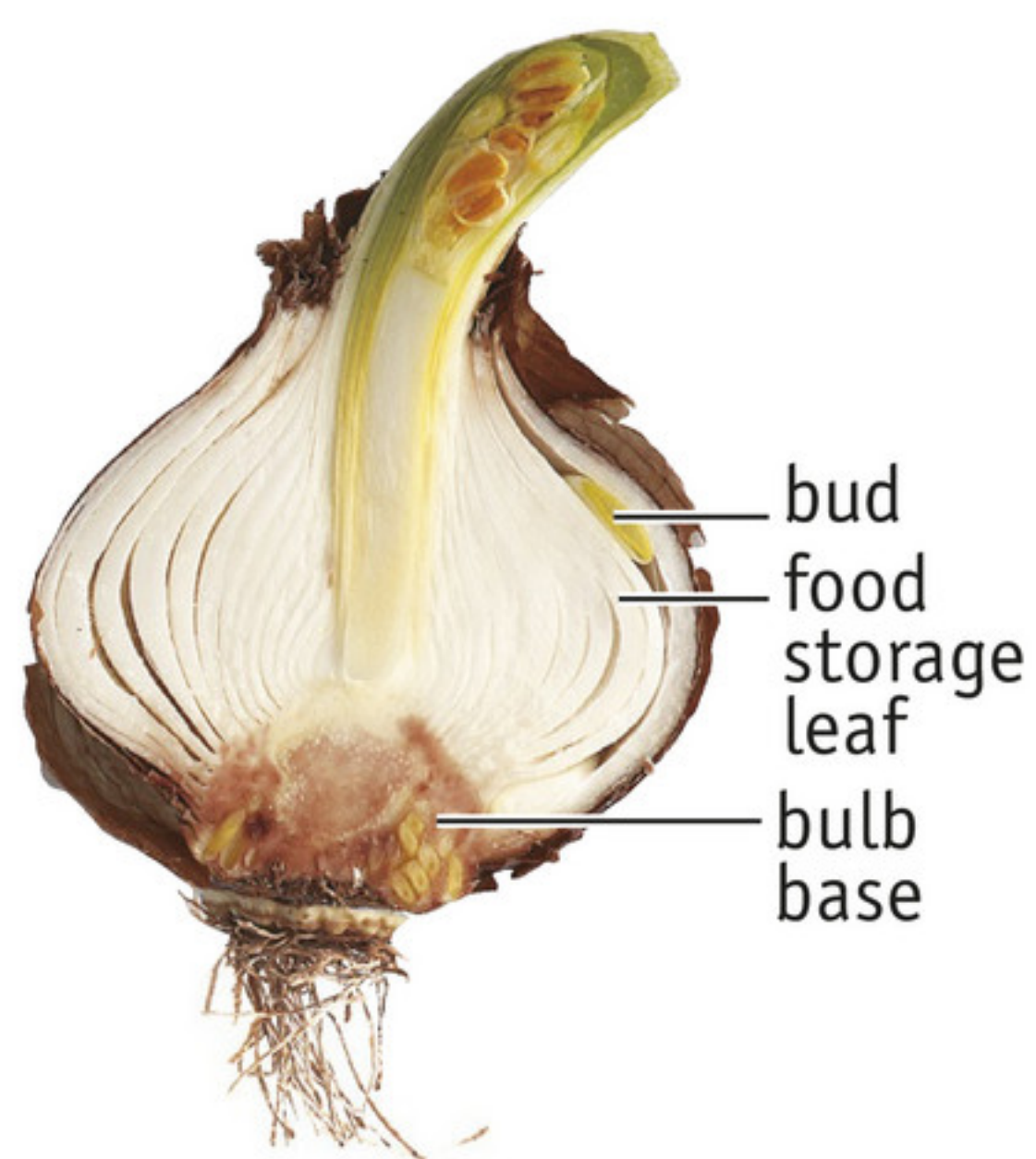
A potato is a tuber (see figure 36). A tuber has **buds**. In the case of a potato, the buds are called 'eyes'.

▼ **Fig. 37** Asexual reproduction by tubers (potato plant).

In the spring, the buds start to grow. A bud that grows will produce a potato plant (see figure 37). Part of the parent plant has therefore grown into a new plant.



▼ **Fig. 38** Cross section of a daffodil bulb.

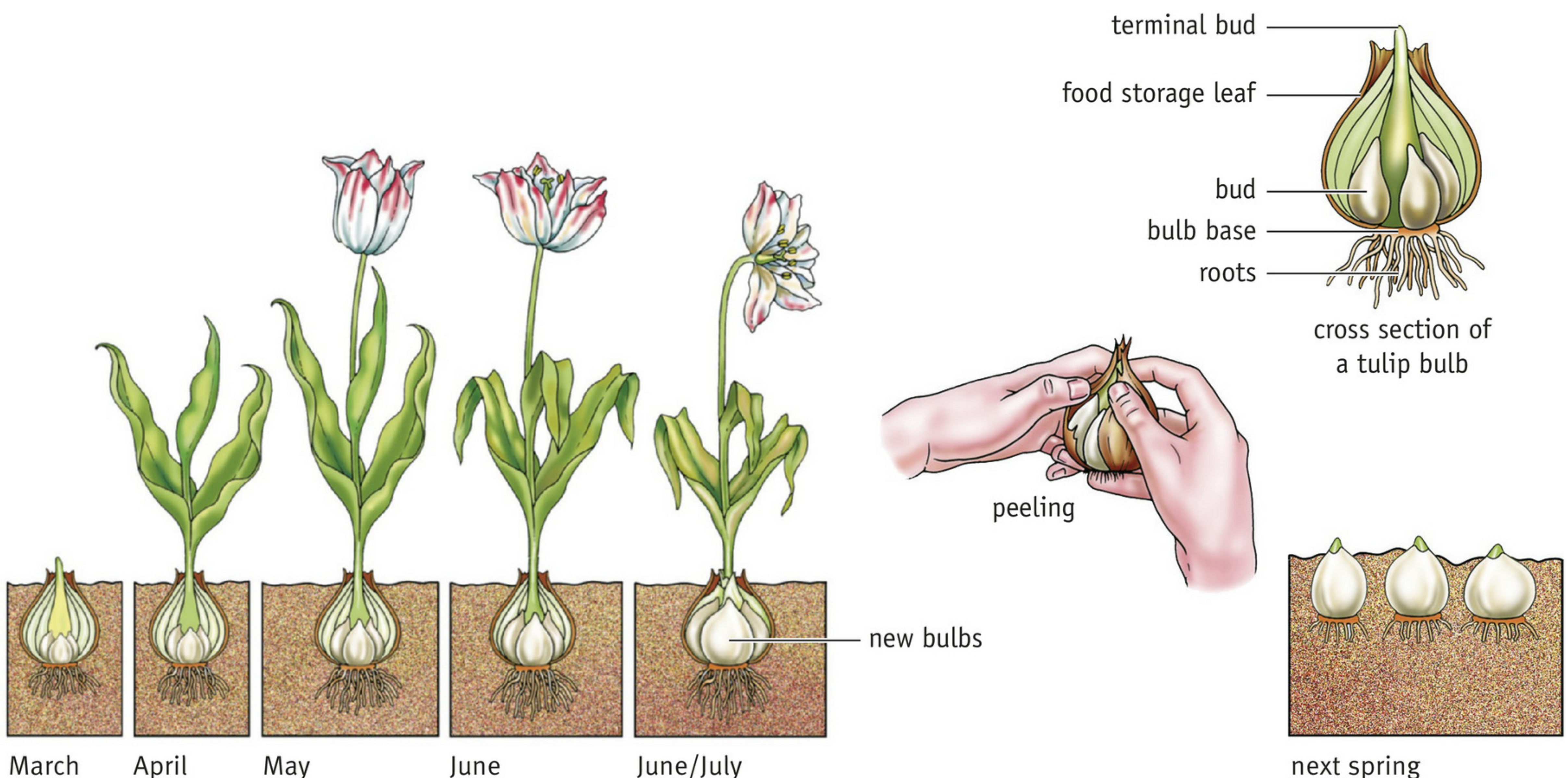


BULBS

Onions, daffodils and tulips are bulb crops. These are crops in which asexual reproduction takes place through **bulbs**. Figure 38 shows a daffodil bulb. A bulb consists of a **bulb base** and **food storage leaves**. These are thickened leaves that contain a lot of stored food. There are **buds** between the storage leaves.

Tulip bulbs are planted in the soil in the autumn. When the tulip bulb starts to grow in the spring, a new plant develops from the **terminal bud** (see figure 39). Part of the parent plant has therefore grown into a new plant.

▼ **Fig. 39** Asexual reproduction by bulbs (tulip).

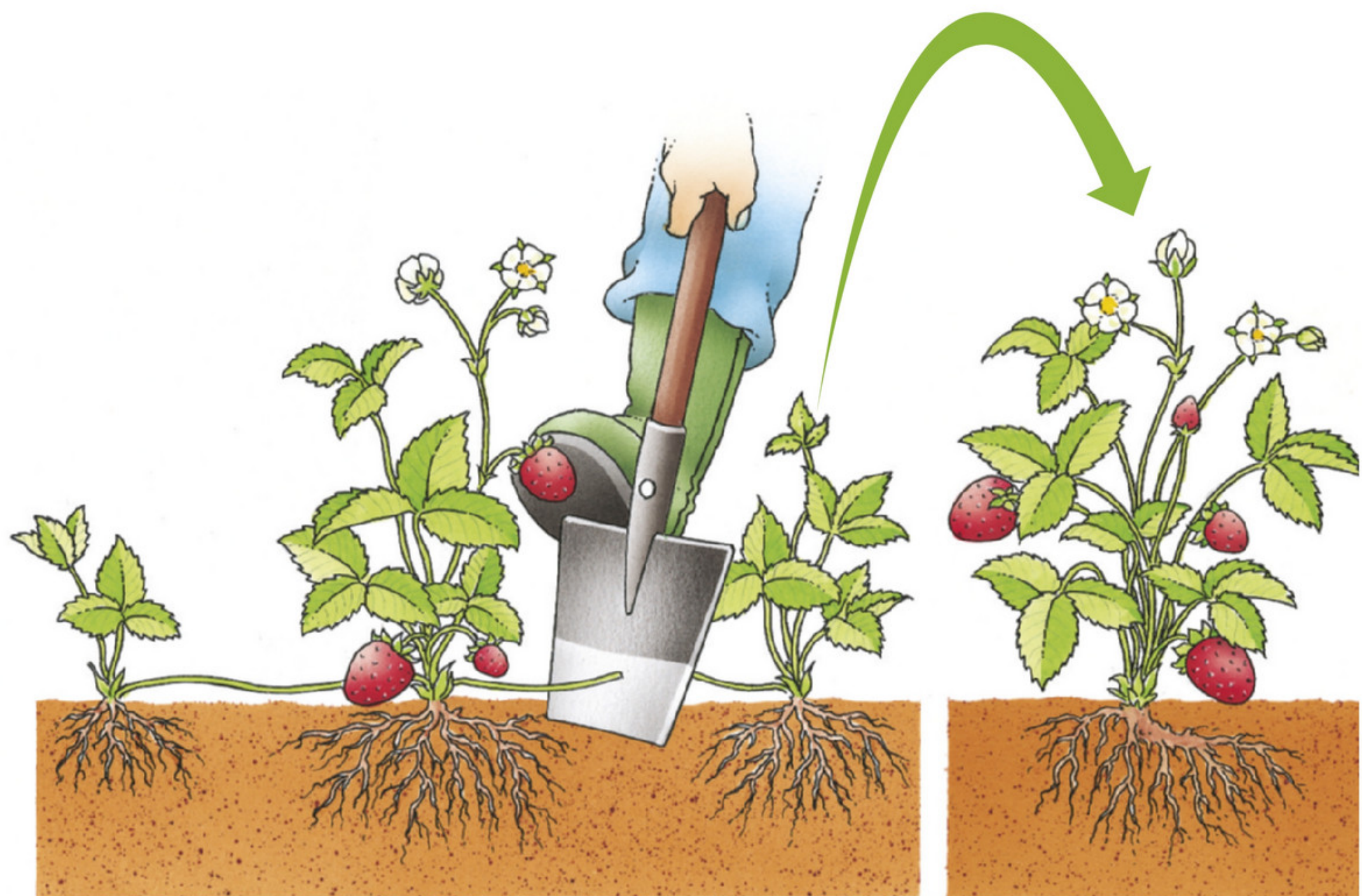


RUNNERS AND RHIZOMES

Figure 40 shows a strawberry plant. Strawberry plants have **runners**. These are stems from which new plants can grow at various places. If these young plants are separated from the parent plant, they can develop on their own. In this way, part of a strawberry plant (a young plantlet on a runner) can grow into a new strawberry plant.

In lily-of-the-valley, young plants can grow from runners that are roots rather than stems: **rhizomes** (see figure 41). Like runners, rhizomes are also stems that young plants can grow from. These young plants can also develop on their own if they are separated from the parent plant.

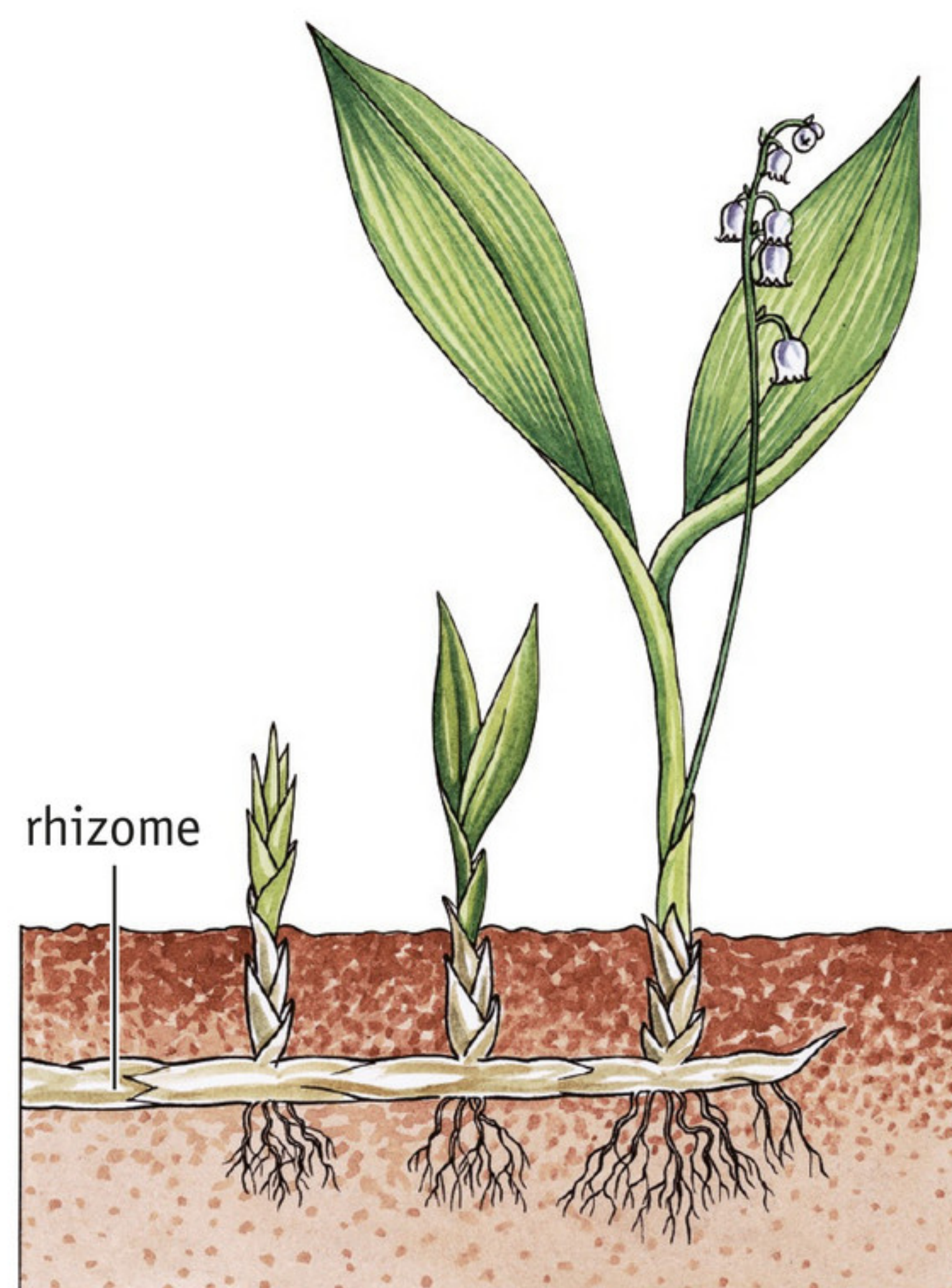
► **Fig. 40** Asexual reproduction by runners (strawberry).



1 young plants on runners

2 new plant

► **Fig. 41** Asexual reproduction by rhizomes (lily-of-the-valley).

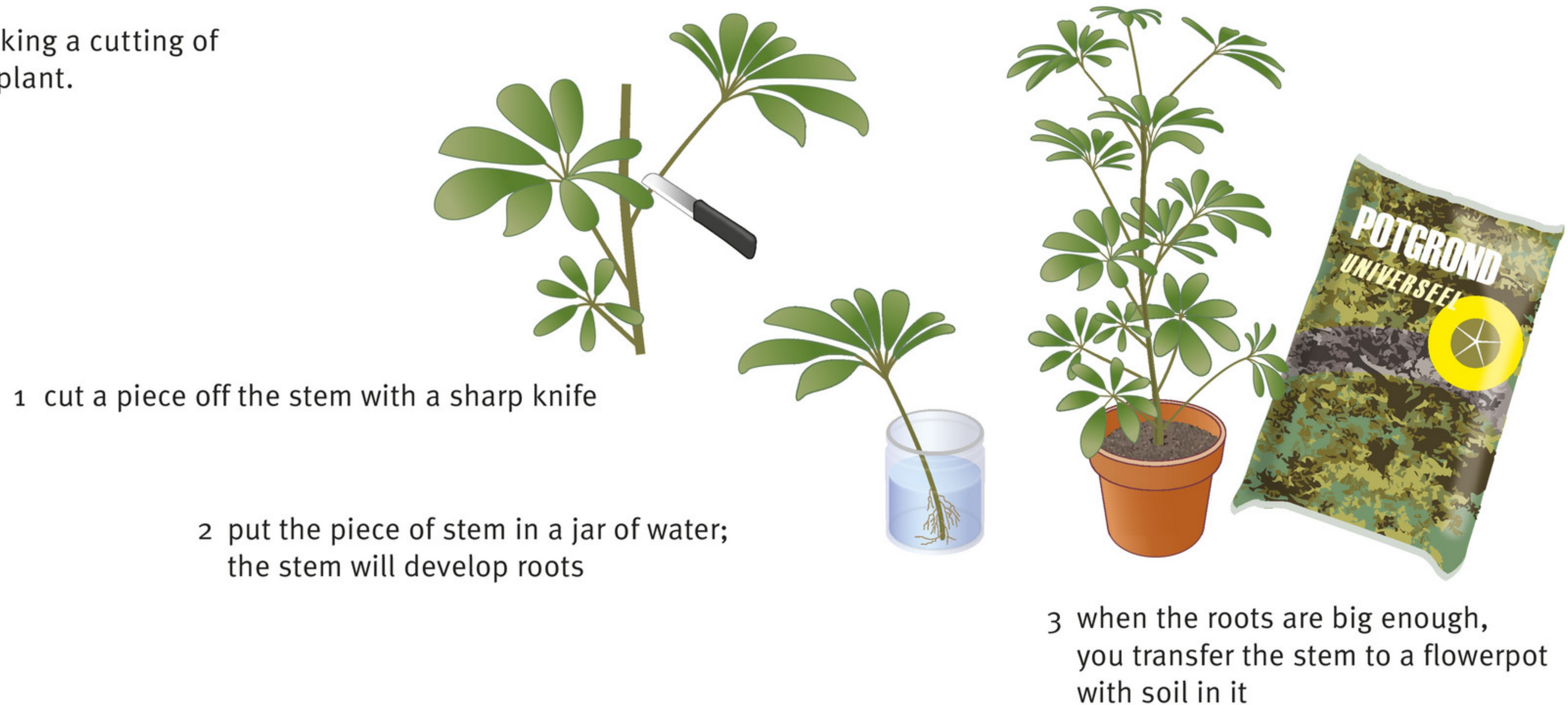


CUTTINGS

Plant growers use asexual reproduction a lot. They call this plant **propagation**.

You can also propagate plants yourself, for example by taking a **cutting** of an indoor plant. Figure 42 shows you how to do this.

▼ **Fig. 42** Taking a cutting of an indoor plant.



TISSUE CULTURE

A special method of plant propagation is **tissue culture** (see figure 43). The plant grower uses a sharp knife to cut off the axillary buds or terminal buds of a plant. A cut-off bud like this is called a **growing tip**. The grower puts the growing tips into test tubes containing special nutrients (see figure 44). The growing tips then develop into small plants. The nutrient medium contains all the substances that the small plants need. The nutrient medium also contains special compounds that ensure rapid growth of the plantlets.

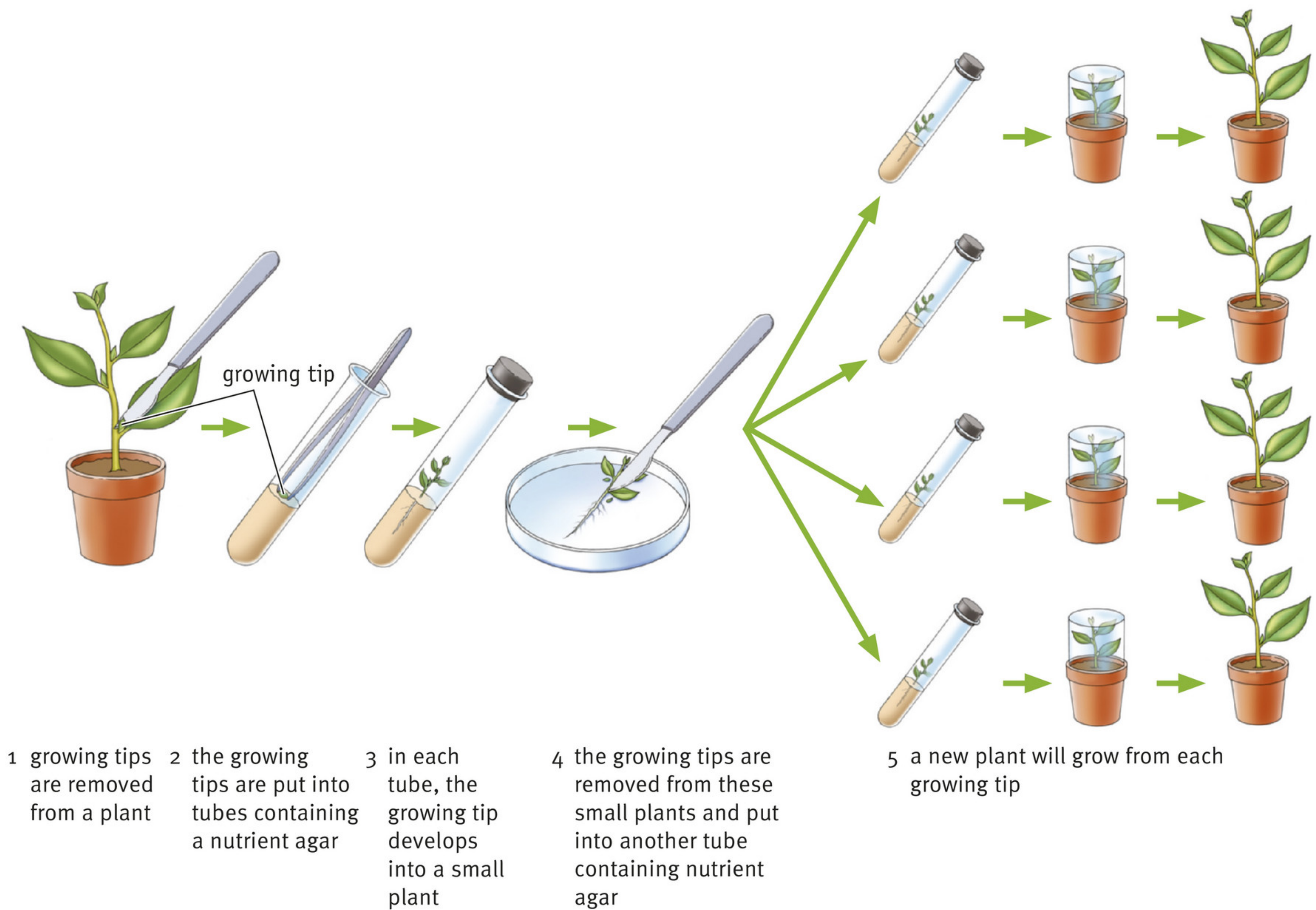
► **Fig. 43** Asexual reproduction by tissue culture.



After about six weeks, new growing tips will appear on each of the plantlets. These can once again be put in test tubes containing the nutrient medium, producing even more new plants. Within one year, this method lets the grower grow more than fifty thousand new plants from a single parent plant. After a few weeks, the plants get new nutrient medium that makes sure they grow bigger and stronger. After that they can be put into normal soil.

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▼ **Fig. 44** Tissue culture.



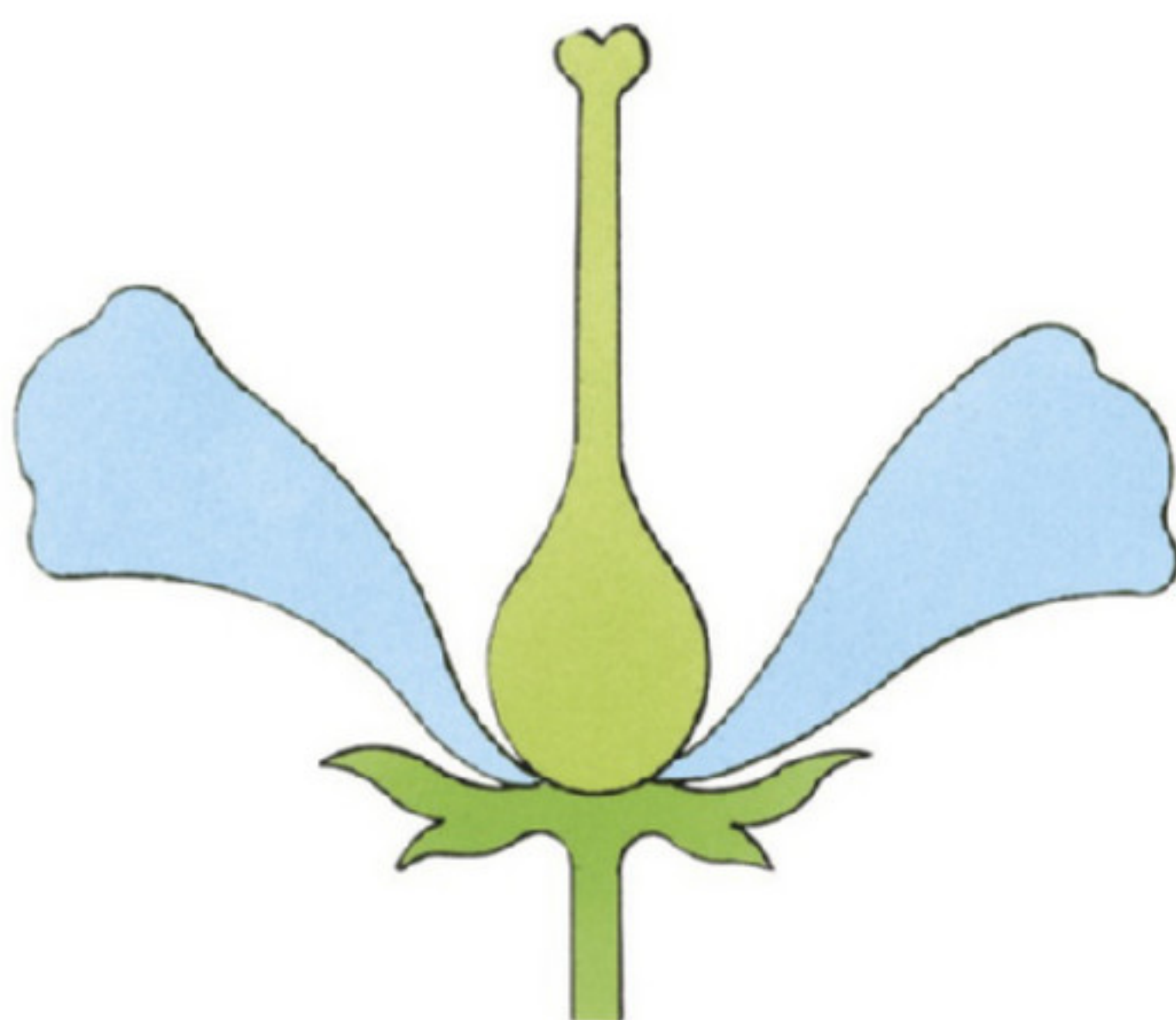
7 Male and female flowers

Most flowers have both stamens and carpels. These flowers are termed **bisexual**. In some plants, though, the flowers only have stamens or only have carpels. These flowers are called **unisexual** (see figure 45). Flowers containing only stamens are called **male flowers**. Flowers containing only carpels are referred to as **female flowers**.

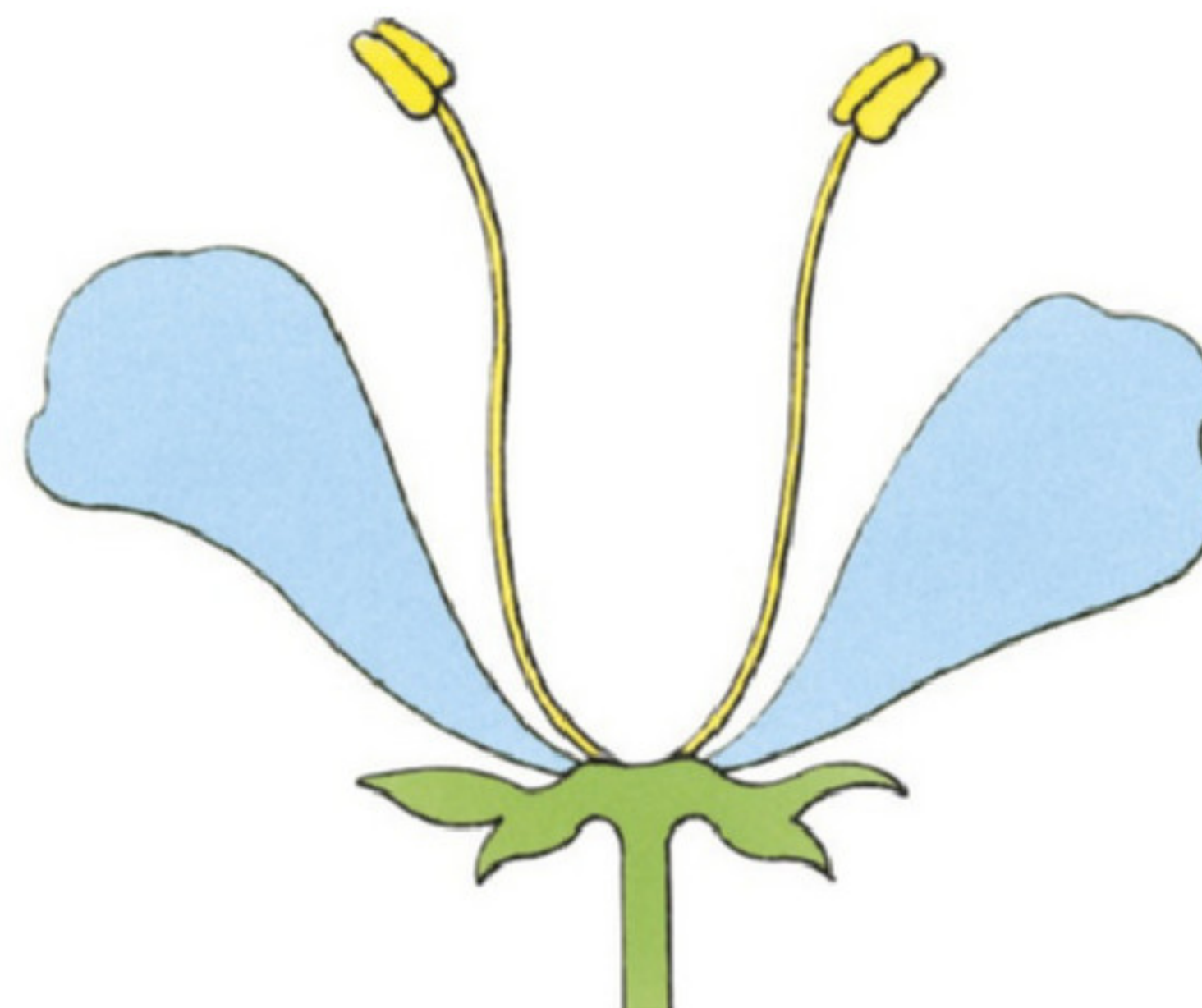
Figure 46.1 shows a willow. A willow has clusters of unisexual flowers. A cluster of flowers like this is called a **catkin**. The catkins with stamens are called male catkins, and the catkins with carpels are called female catkins. A single willow tree has either only male catkins or only female catkins. Plant species in which the individual plants have either male flowers or female flowers (but not both) are called **dioecious** (Greek for 'two houses'). Plant species in which both male and female flowers are found on the same plant are called **monoecious**.

▼ Fig. 45 Types of flowers.

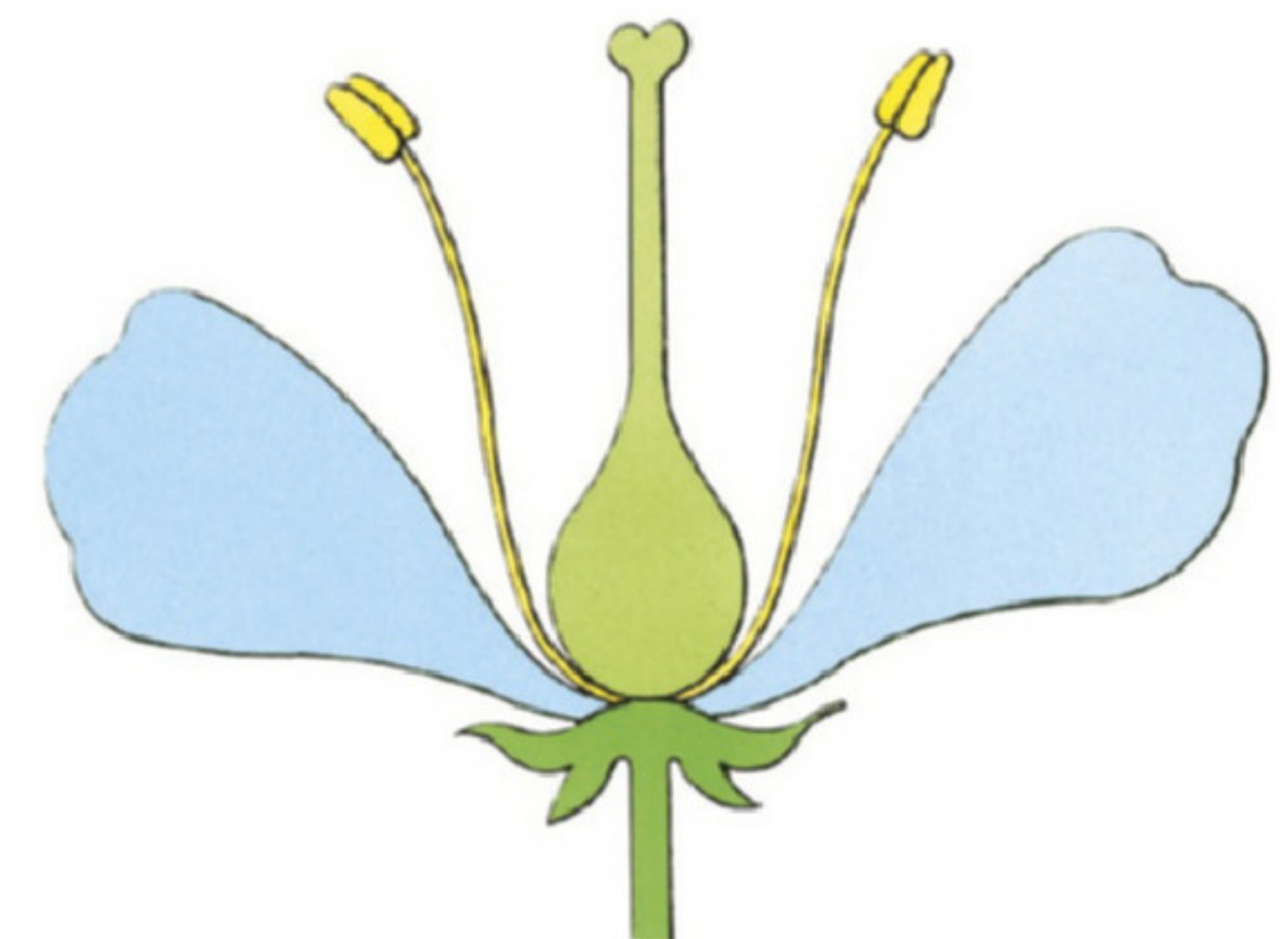
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1 unisexual flower (female)



2 unisexual flower (male)



3 bisexual flower

▼ Fig. 46 Pollarded willow.



1



2 male catkin



2 female catkin

Summary

OBJECTIVE 1

You must be able to name the parts of a flower and their features and functions.

- Calyx (sepals).
 - Usually green.
 - Function: to protect the flower in the bud against dehydration and against the cold.
- Corolla (petals).
 - Often large and brightly coloured, sometimes small and green.
 - Function (if they are brightly coloured): to attract insects.
- Stamen: male reproductive organ.
 - Filament and anther with pollen sacs.
 - Function: to produce pollen grains (male sex cells) in the pollen sacs.
- Carpel: female reproductive organ.
 - Stigma(s), style(s) and ovary with one or more ovules.
 - Function: to produce egg cells (female sex cells) in the ovules. Each ovule produces a single egg cell with a nucleus.

OBJECTIVE 2

You must be able to describe what pollination is and you must be able to tell the difference between cross-pollination and self-pollination.

- Pollination: transferring pollen from a stamen to the stigma(s) of a flower of the same plant species.
- Cross-pollination: pollen from a stamen gets onto the stigma of another plant (of the same species).
 - Cross-pollination is done mostly by insects and by the wind.
- Self-pollination: pollen from a stamen gets onto a stigma of the same plant.

OBJECTIVE 3

You must be able to list the features of insect-pollinated flowers and wind-pollinated flowers.

- Insect-pollinated flowers: flowers in which pollination is done by insects.
 - The flowers are usually large, brightly coloured, scented and contain nectar.
 - The pollen grains are rough and sticky.
 - The stamens and the stigmas are inside the flower.

- Wind-pollinated flowers: flowers in which pollination is done by the wind.
 - The flowers are generally small and inconspicuously coloured, unscented and do not contain nectar.
 - The pollen sacs hang outside the flower. They produce a large amount of pollen that is smooth and light.
 - The stigmas are usually outside the plant and they are feathery.

OBJECTIVE 4

You must be able to describe the fertilisation process in seed plants.

- After pollination there will be one or more pollen grains on the stigma.
 - A pollen tube starts to grow from a pollen grain down the style to an ovule.
 - Fertilisation: the pollen grain nucleus fuses with the egg cell nucleus.
 - The ovule then contains an embryo.
- New varieties of plant can be produced by crossing them.

OBJECTIVE 5

You must be able to describe the changes that take place in the ovary after fertilisation.

- The plant embryo (or germ) develops.
 - When a seed germinates, the germ grows into a seedling.
- An ovule (with a plant embryo) develops into a seed.
 - A seed contains a reserve of food for the seedling.
 - Examples of seeds: apple pips, cherry stones, tomato pips, beans in pods.
- An ovary grows into a fruit.
 - Examples of fruits: apples, cherries, tomatoes, bean/pea pods.

OBJECTIVE 6

From pictures of (parts of) a plant, you must be able to tell how the fruits and seeds of the plant are dispersed.

- Dispersal by the plant itself.
 - Fruits burst open and the seeds are ejected.
 - Examples: bean, broom, pea, cranesbill, balsam.
- Dispersal by the wind.
 - Fruits (containing seeds) with fluff or wings.
 - Examples: creeping thistle, ash, maple, lime, dandelion.

- Dispersal by animals.
 - Fruits (berries) are eaten and the seeds are passed through undigested in the droppings, e.g. holly, rowan.
 - Winter stocks are not completely eaten or are forgotten, e.g. fruits of the oak (acorns) and beech (beech nuts).
 - Fruits with hooks stick onto the fur of animals, e.g. burdock, burr marigold.

EXTRA OBJECTIVE 7

You must be able to describe how asexual reproduction of seed plants takes place and give examples.

- Asexual reproduction: part of the parent plant grows into a new plant.
- Tuber: a thickened stem with reserves of food and buds.
 - When a tuber starts to grow, a new plant comes from one of the buds.
 - New tubers grow from each of these plants, and those tubers can in turn grow into new plants.
 - Example: the potato plant.
- Bulb: has a bulb base, thickened leaves for storing food, and buds.
 - When a bulb starts to grow, a new plant grows from one of the buds (the terminal bud).
 - The other buds develop into new bulbs, each of which can in turn develop into a plant.
 - Example: tulip.
- Runner: a stalk above the ground from which young plants can grow at various places.
 - If the young plants are separated from the parent plant, they can develop on their own.
 - Example: strawberry plant.
- Rhizomes: a stalk below the ground from which young plants can grow at various places.
 - If the young plants are separated from the parent plant, they can develop on their own.
 - Example: lily-of-the-valley.
- Cuttings: a piece of a stem or leaf is cut off.
 - The cutting grows into a new plant.
 - Example: indoor plants.
- Propagation: asexual reproduction as used by plant growers.
- Tissue culture: growing tips (terminal buds and axillary buds) are cut off and placed in a special nutrient agar.
 - Each growing tip grows into a new plant.
 - Tissue culture can produce a large number of plants very quickly.

EXTRA OBJECTIVE 8

You must be able to describe what unisexual and bisexual flowers are and what monoecious and dioecious plant species are.

- Unisexual flowers: contain only stamens or only carpels.
 - Male catkin: cluster of male flowers.
 - Female catkin: cluster of female flowers.
- Bisexual flowers: contain both stamens and carpels.
- Monoecious plant species.
 - Plants with bisexual flowers and species that have male and female flowers on the same plant.
 - Self-pollination is possible in monoecious plant species.
- Dioecious plant species.
 - Species in which any one plant has only male or only female flowers.
 - Self-pollination is not possible in dioecious plant species.

SKILLS AND COMPETENCIES**BASICS**

- You have practised searching for information on the Internet.
- You have practised making drawings.
- You have practised preparing slides.
- You have practised using the microscope.

EXTRA

- You have practised making drawings.

The diagnostic test does not include any questions about these skills and competencies.

You have met a plant breeder and a fruit grower in this unit. You have also seen applications of biology in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

Answer the following questions.

- 1 What colour are the sepals usually?
- 2 Are petals male sex organs?
- 3 What are the male sex cells of a plant called?
- 4 What are the female sex organs of a plant called?
- 5 What is the function of part P in figure 47?

▼ Fig. 47



Figure 48 is a drawing of a flower. Questions 6 to 10 are about this figure.

- 6 Which number shows a petal?
- 7 Which part are the egg cells produced in?
- 8 Which numbers together define the carpel?
- 9 Which part are male sex cells formed in?
- 10 What is the function of part number 4?

▼ Fig. 48

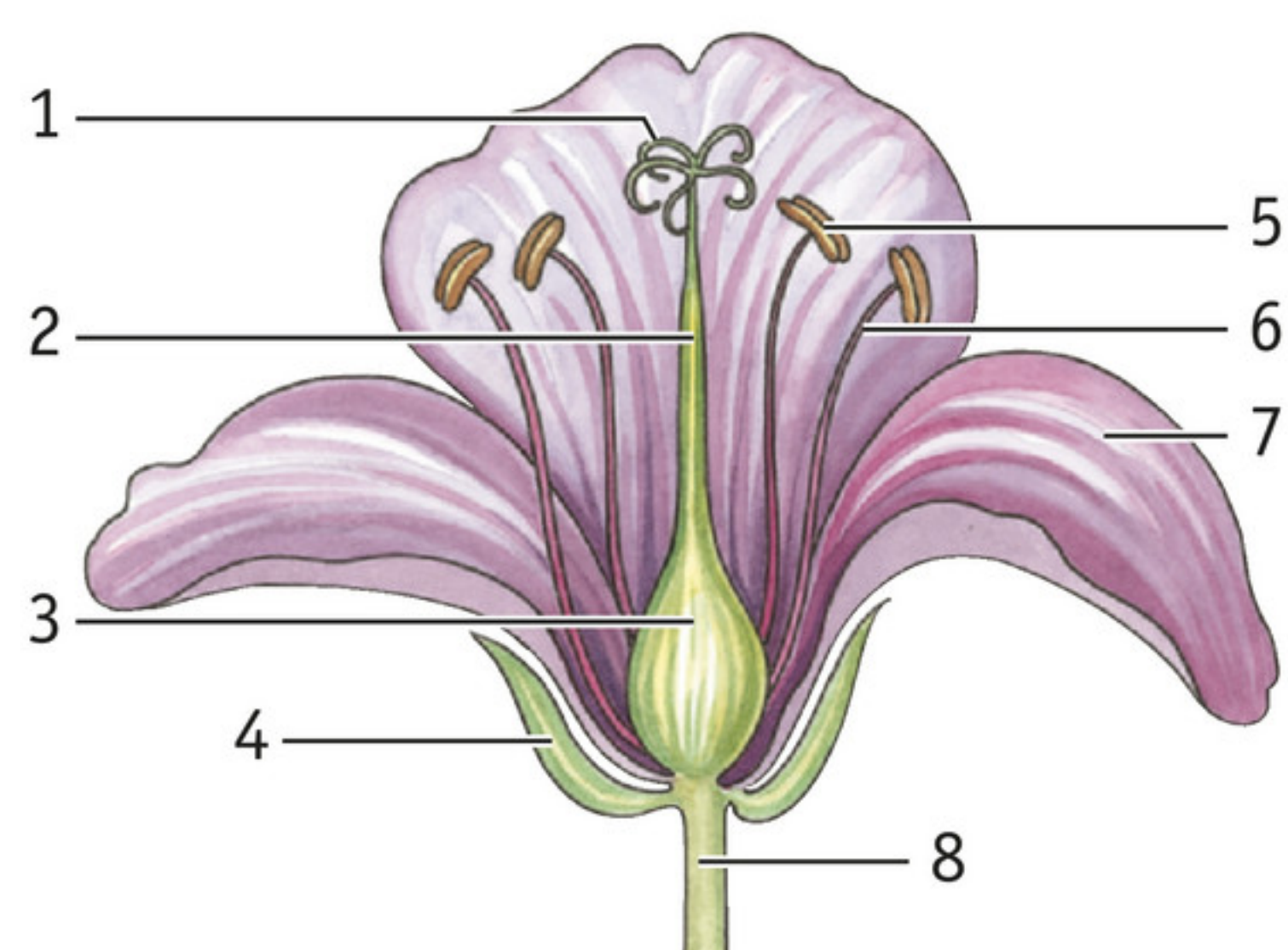
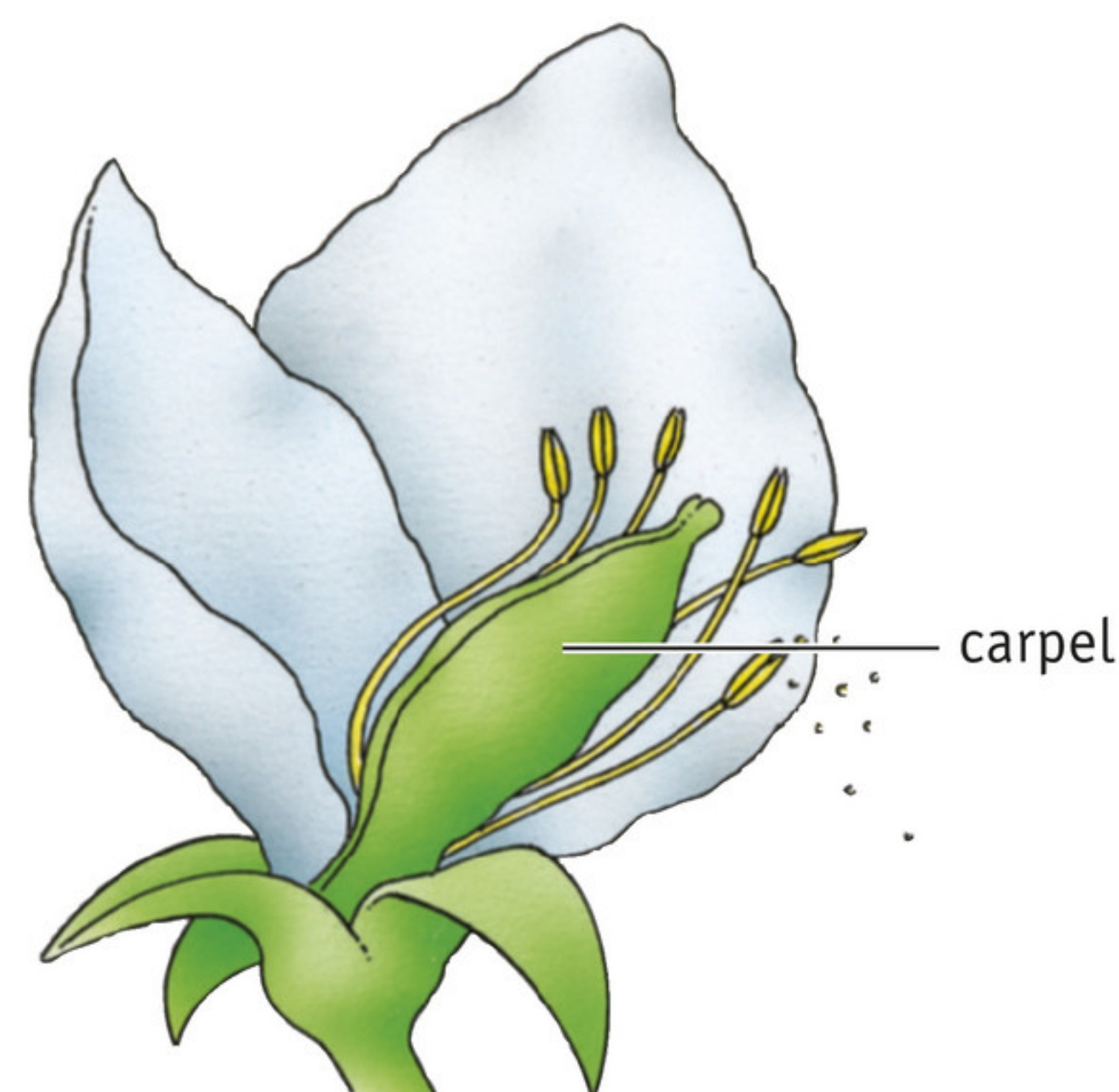


Figure 49 shows a drawing of a flower from a pea plant. In this flower the carpel is indicated. Questions 11 and 12 are about this figure.

- 11 Can the ovary of this carpel contain more than one ovule?
- 12 Can an ovule in this carpel contain more than one egg cell?

▼ Fig. 49



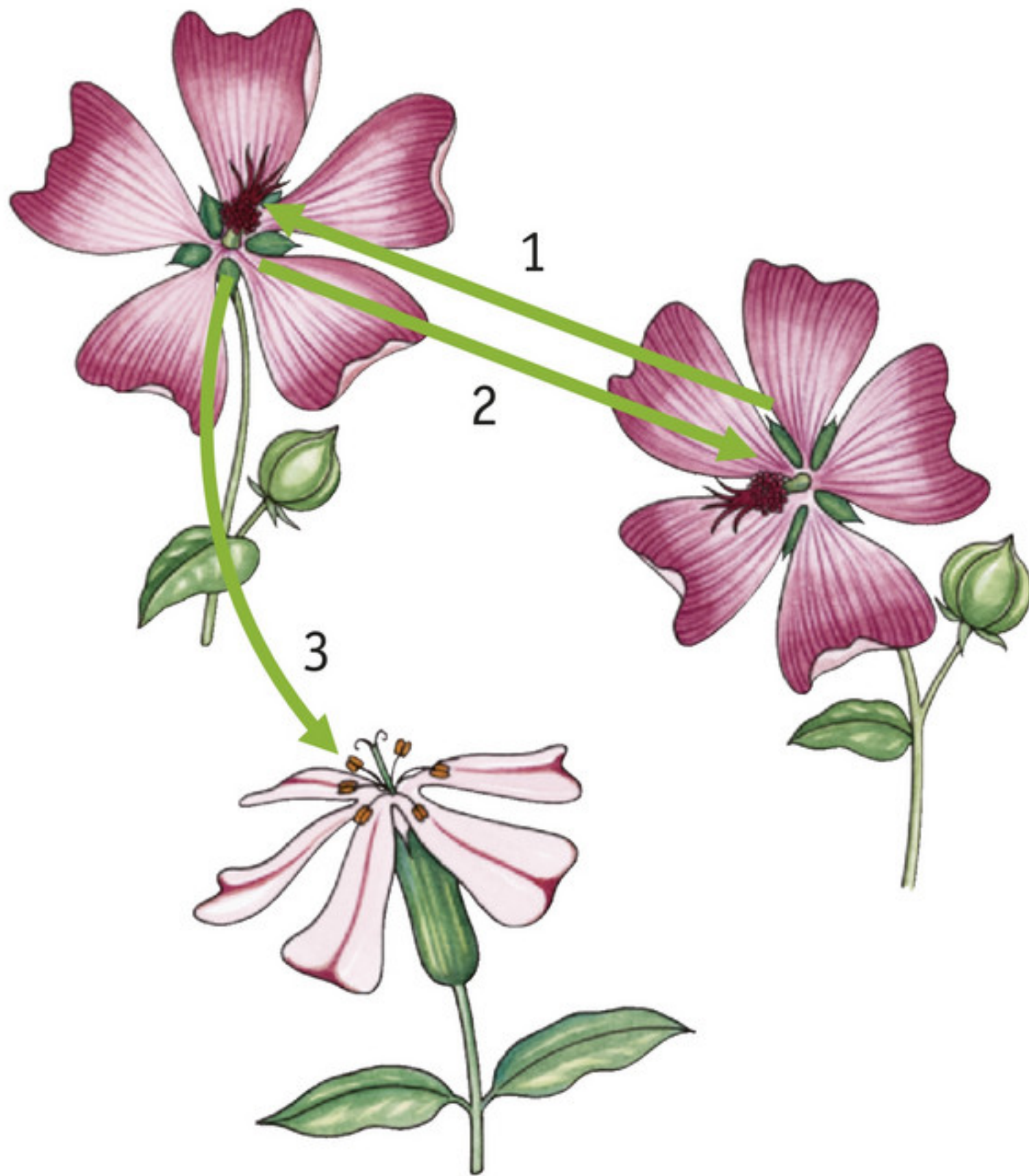
OBJECTIVE 2

Answer the following multiple choice questions.

- 1 What is pollination?
 - A Growth of a pollen tube down the style of a stamper of the same plant species.
 - B The transfer of pollen from a stamen to the stigma(s) of a flower of the same plant species.
 - C Fusion of the nuclei of a pollen grain and an egg cell of the same plant species.
 - D The release of pollen from the pollen sacs of a stamen.

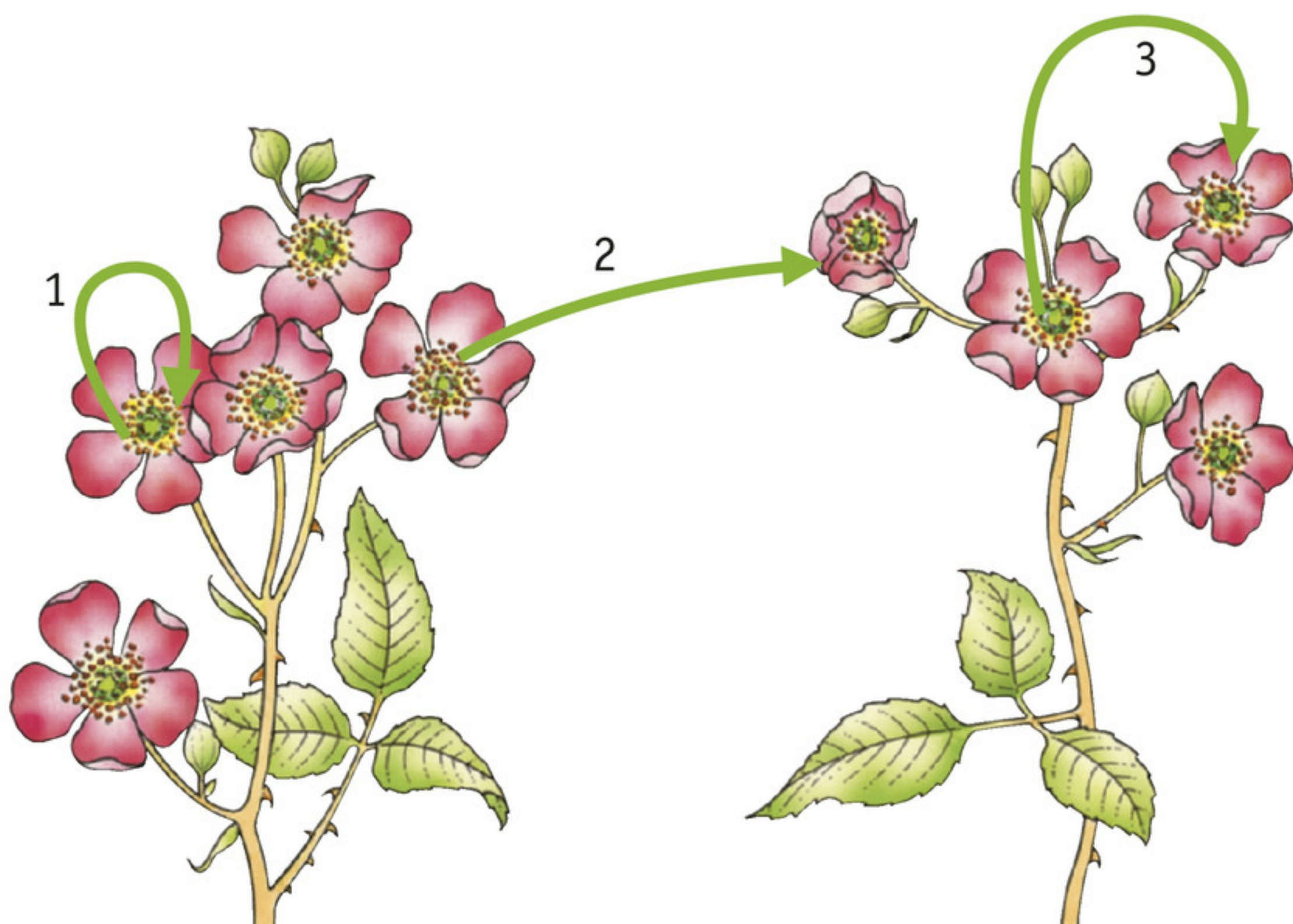
- 2 Figure 50 shows a drawing of three flowering plants. Insects can pass on pollen grains as indicated by the arrows. Which arrow or arrows indicate pollination?
- A Only arrow 1.
 - B Only arrow 3.
 - C Only arrows 1 and 2.
 - D Arrows 1, 2 and 3.

▼ Fig. 50



- 3 Figure 51 is an illustration of two flowering elmleaf blackberry plants. Insects can pass on pollen grains as indicated by the arrows. Which arrow or arrows indicate self-pollination?
- A Only arrow 1.
 - B Only arrow 2.
 - C Only arrows 1 and 3.
 - D Arrows 1, 2 and 3.

▼ Fig. 51



OBJECTIVE 3

Answer the following questions.

- 1 Sometimes you can see yellow powder on cars after a shower. This is pollen. Will this pollen mostly come from insect-pollinated flowers or from wind-pollinated flowers?
- 2 Figure 52 is a drawing of a rye plant's flower. Will rye flowers contain nectar? Explain your answer.

▼ Fig. 52

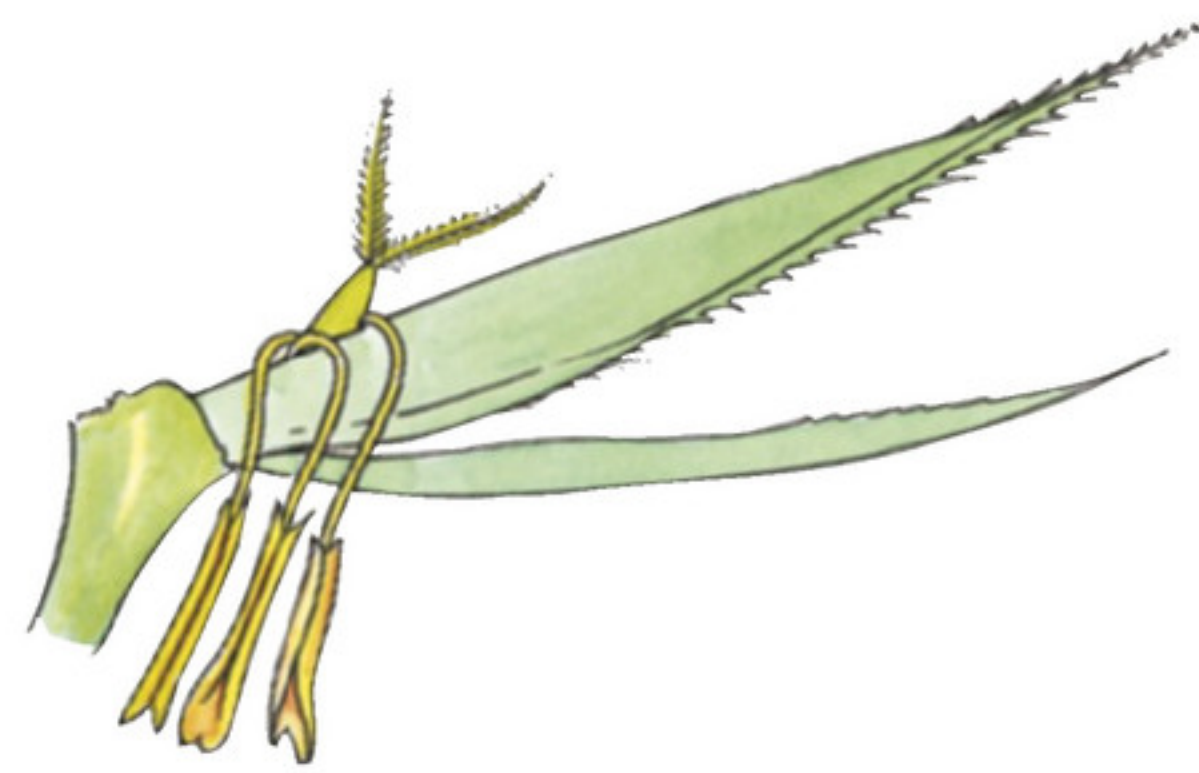


Figure 53 is a photo of two pollen grains. This picture is to be used for questions 3 and 4.

- 3 Will these pollen grains be transferred by insects or by the wind? Explain your answer.
- 4 Might you find pollen grains like these in honey? Explain your answer.

▼ Fig. 53 Pollen grains (1500× magnification).



- 5 Ragweed is a plant that used only to be found in America. Nowadays it can also be found in large parts of the Netherlands. Ragweed blooms late in the year, which is a nuisance for hay fever sufferers. Would you expect that the anthers and stigmas of ragweed protrude outside the flowers? Explain your answer.
- 6 Figure 54 is part of the description of a plant in a plant guide. How is the pollen dispersed in this plant: by insects or by the wind?

▼ Fig. 54

Three-nerved sandwort

The three-nerved sandwort (*Moehringia trinervia*) gets its name from the clearly visible parallel veins in its leaves. It is a weed that can be found throughout Europe. The flowers are usually small and white, or sometimes lilac. The petals are shorter than the sepals. The petals are not fused. The carpel and the stamens are shorter than the petals.



OBJECTIVE 4

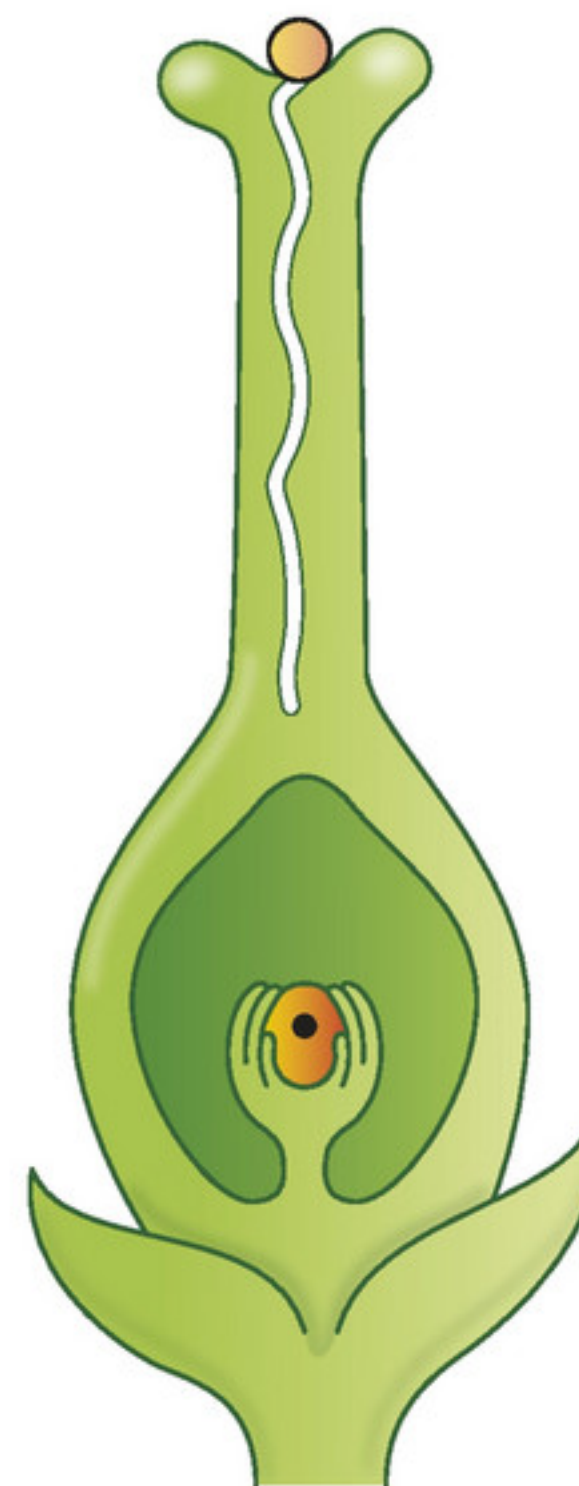
Say whether each of the following statements is true or false.

- 1 In seed plants, fertilisation takes place first and then pollination.
- 2 Fertilisation takes place at the moment that a pollen tube grows out of a pollen grain.
- 3 A pollen tube grows down inside the style towards an ovule.
- 4 Fertilisation can take place only once in an ovary.
- 5 Fertilisation can take place only once in an ovule.

Figure 55 is a schematic drawing of a carpel. Statements 6 and 7 are about this figure.

- 6 Pollination has already taken place in this figure.
- 7 Fertilisation has already taken place in this figure.

▼ Fig. 55



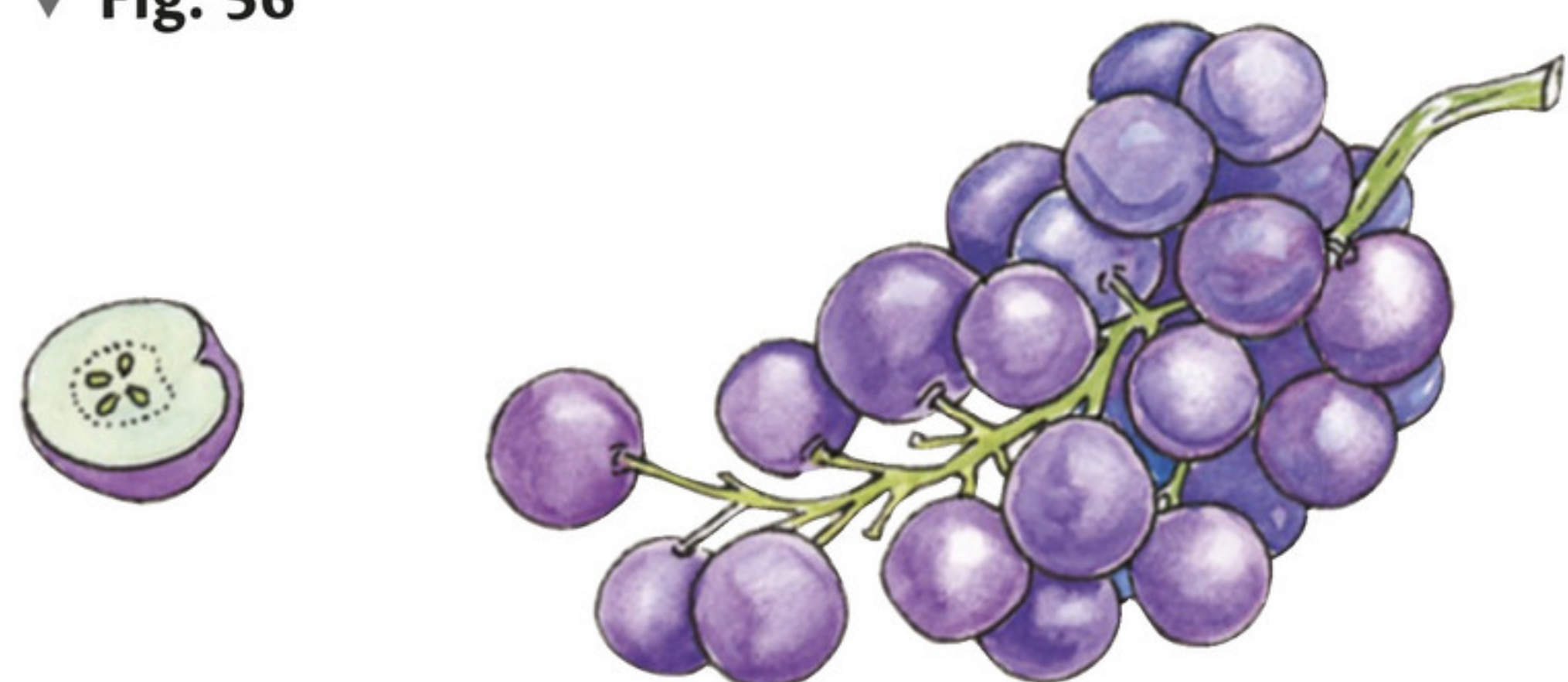
- 8 Crossing plants is done by self-pollination.

OBJECTIVE 5

Answer the following multiple choice questions.

- 1 Here are three events that play a part in producing the fruit.
 - 1 A fertilised egg cell develops into an embryo.
 - 2 The nucleus of a pollen grain fuses with the nucleus of the egg cell.
 - 3 A mature fruit is produced.
 What is the correct sequence for these events when a seed is produced?
 - A 1 – 2 – 3.
 - B 1 – 3 – 2.
 - C 2 – 3 – 1.
 - D 2 – 1 – 3.
- 2 Figure 56 shows a bunch of grapes and one grape cut in half. A grape is a fruit. The grapes in this bunch have an average of five pips. How many ovaries were needed to produce this bunch of grapes?
 - A Just one ovary.
 - B Five ovaries.
 - C About 30 ovaries.
 - D About 150 ovaries.

▼ Fig. 56



- 3 Figure 57 is a drawing of a mandarin orange that has been cut in half. This mandarin contains four seeds and grew from a mandarin flower after fertilisation. How often (as a minimum) must fertilisation have occurred in that flower? How many ovaries were needed to produce this mandarin?
- A One fertilisation and one ovary.
 - B One fertilisation and four ovaries.
 - C Four fertilisations and one ovary.
 - D Four fertilisations and four ovaries.

▼ Fig. 57



- 4 Figure 58 shows a drawing of a flower from an apple tree. Fertilisation has taken place. What develops from the ovary after fertilisation?
- A An apple.
 - B An apple seed.
 - C The core of an apple.
 - D The fruit pulp of an apple.

▼ Fig. 58



- 5 Cashew nuts contain a lot of food reserves (see figure 59). What is this food reserve intended for?
- A For the development of the ovule.
 - B For attracting insects.
 - C For protecting the seed.
 - D For the seedling that will appear after germination.

▼ Fig. 59



1 cashew fruit with seed



2 cashew nuts

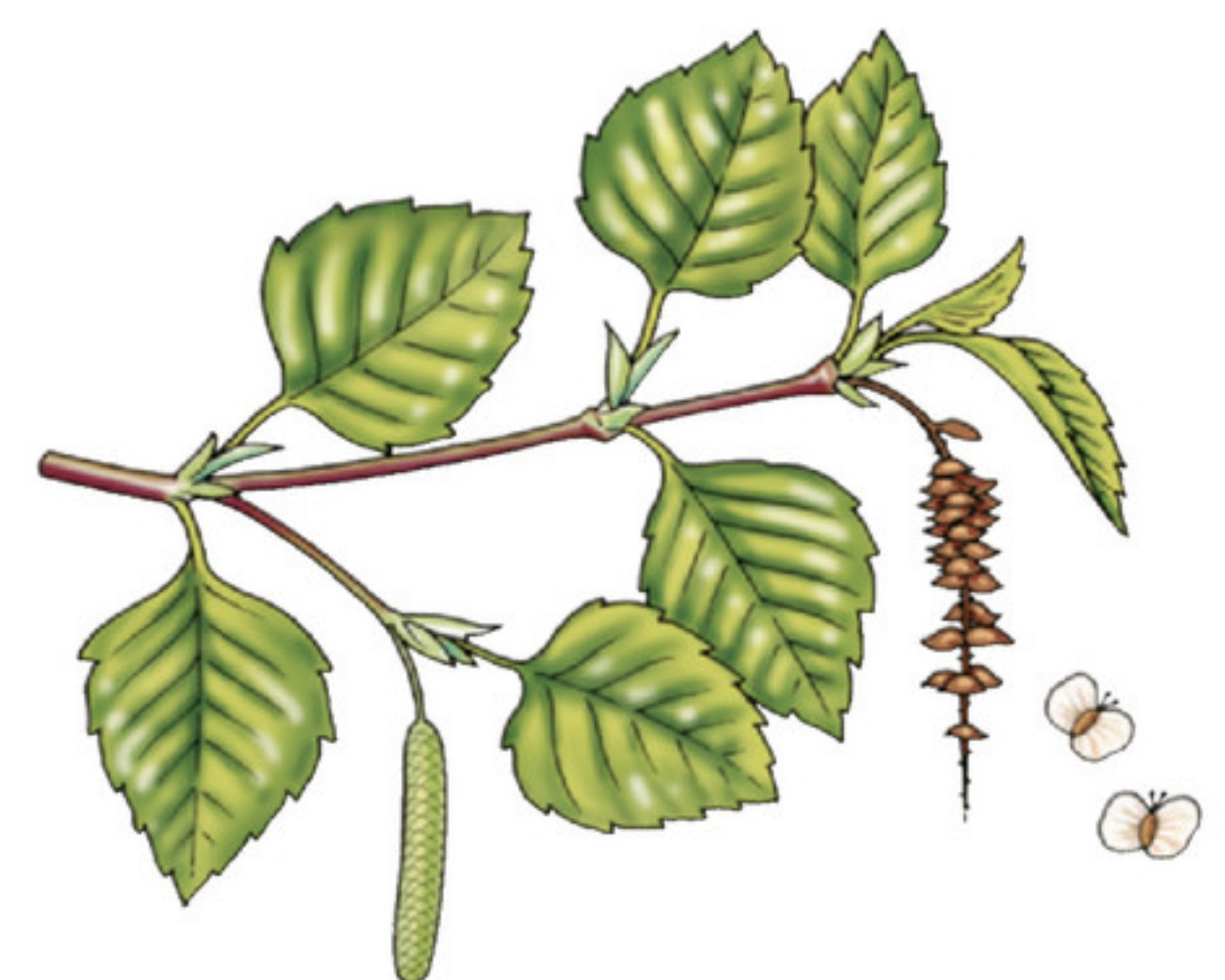
OBJECTIVE 6

Figure 60 shows illustrations of parts of plants containing fruits and seeds. How are the fruits and seeds dispersed? Choose between: *by the plant itself* – *by the wind* – *by animals*.

▼ Fig. 60



1 bramble (blackberry)



2 birch



3 meadow salsify



4 Himalayan balsam



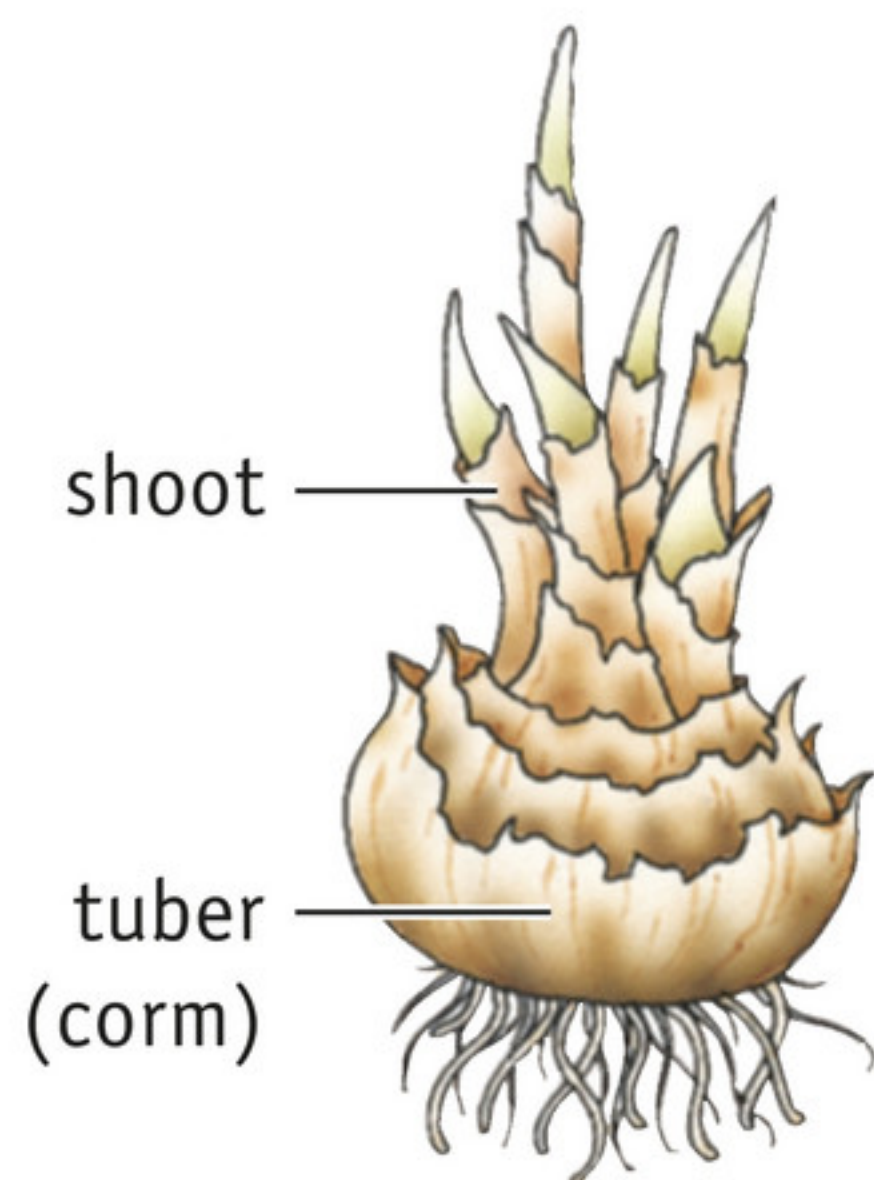
5 burdock

EXTRA OBJECTIVE 7

Answer the following questions.

- 1 Figure 61 is a drawing of a crocus corm with a number of shoots. These shoots can be separated from the corm and will then grow as separate plants. Have the new crocuses been produced by sexual reproduction or by asexual reproduction? Explain your answer.

▼ **Fig. 61** Crocus corm with shoots.



- 2 Figure 62 is a photo of silverweed. What is the name of part P?

▼ **Fig. 62** Silverweed.

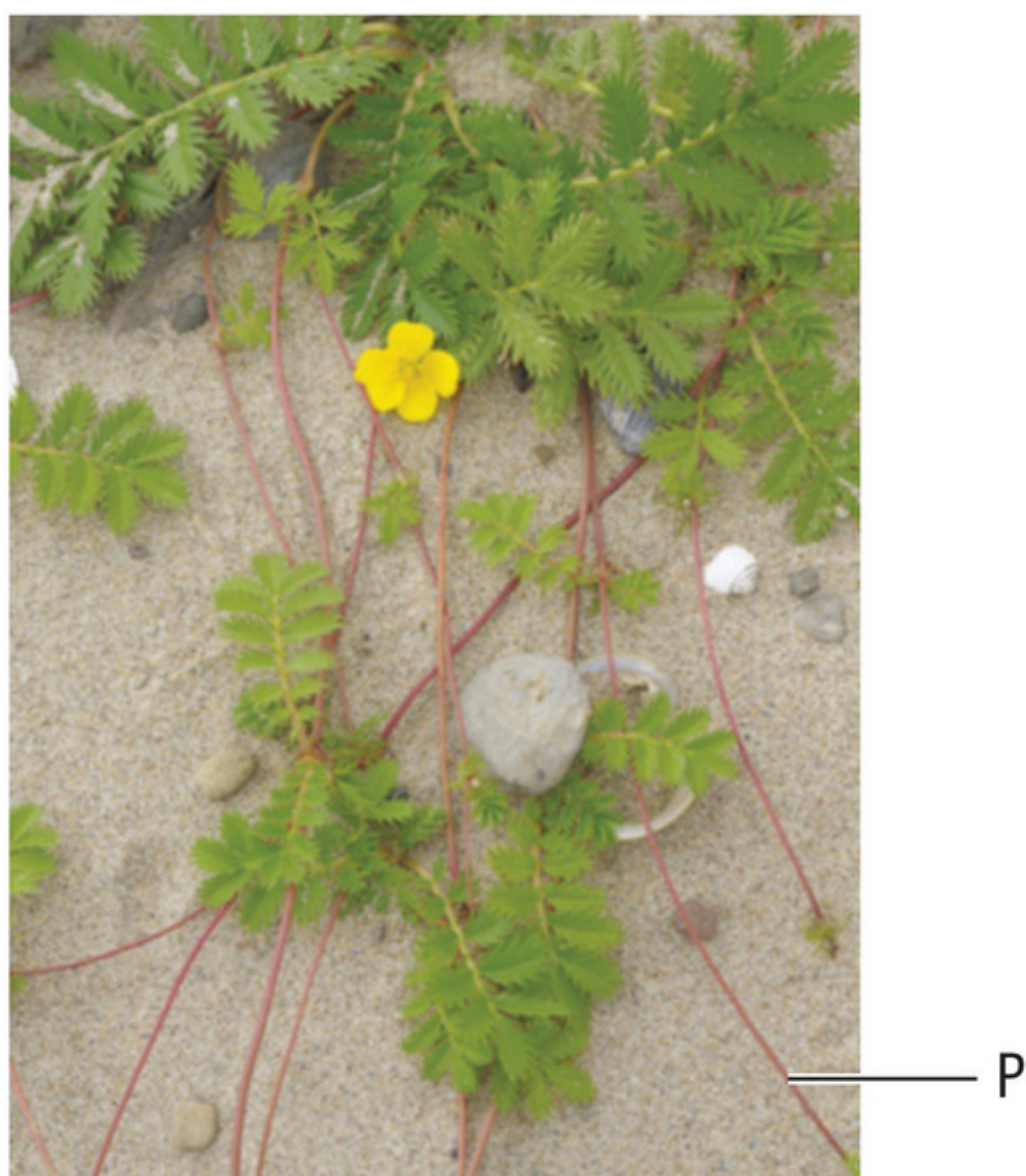
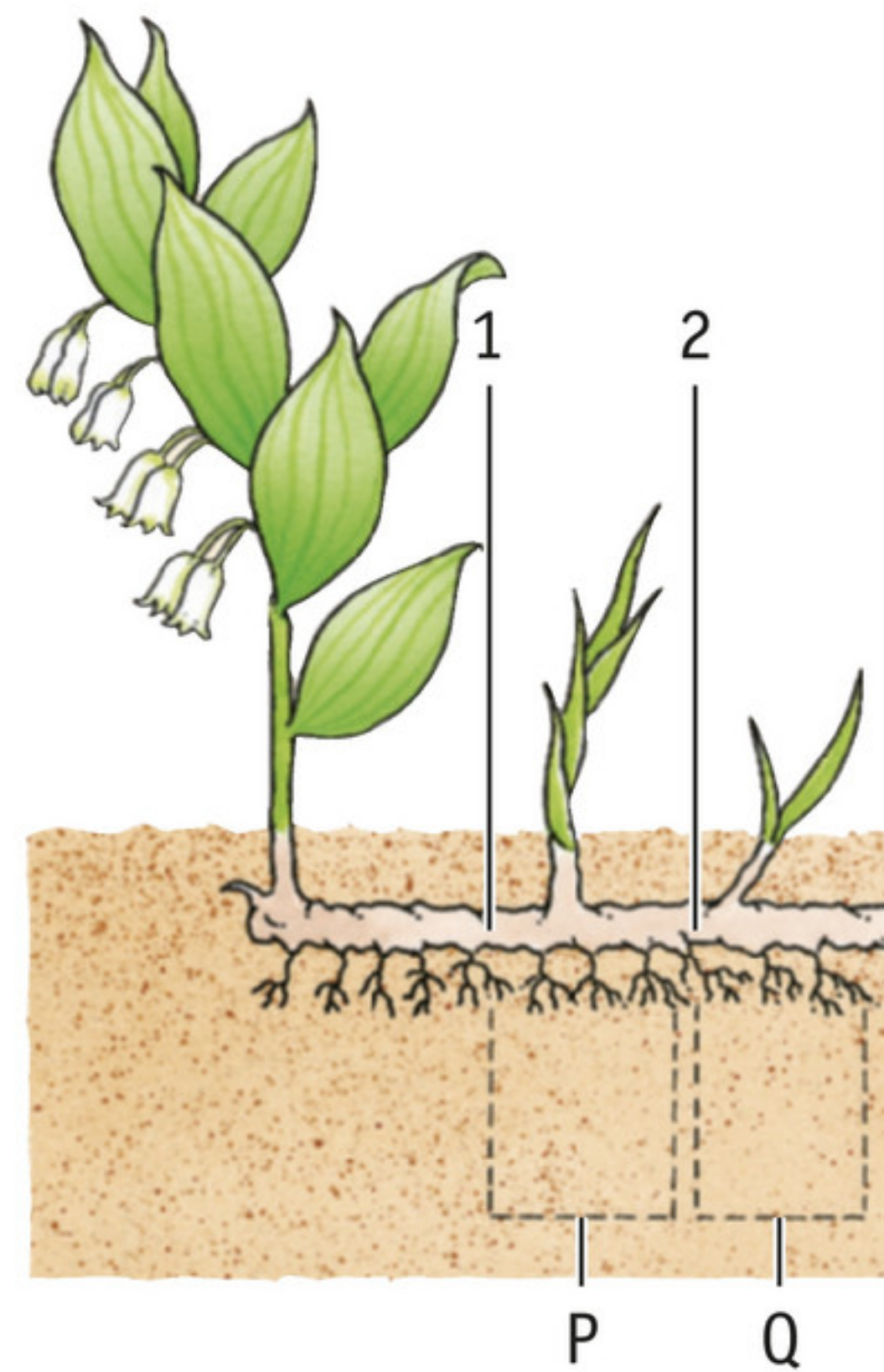


Figure 63 is a drawing of a Solomon's seal. The underground root is cut at points 1 and 2. Sections P and Q develop into independent plants. Questions 3 and 4 are about this drawing.

- 3 What is the name of this underground stem?
4 Parts P and Q become independent plants. Are these new plants the result of sexual reproduction or asexual reproduction?

▼ **Fig. 63**



- 5 Figure 64 shows you a whole Chioggia beet and one that has been cut in half. A Chioggia beet has thickened roots that can be eaten as a vegetable. A student states that the Chioggia beet is a bulb. Explain whether this statement is correct or not.

▼ **Fig. 64**



- 6 Tissue culture is one method of propagation. What advantage does tissue culture have compared with taking cuttings?

The following information is for questions 7 and 8. In figure 65, you can read how tree growers graft apple trees (and other fruit trees).

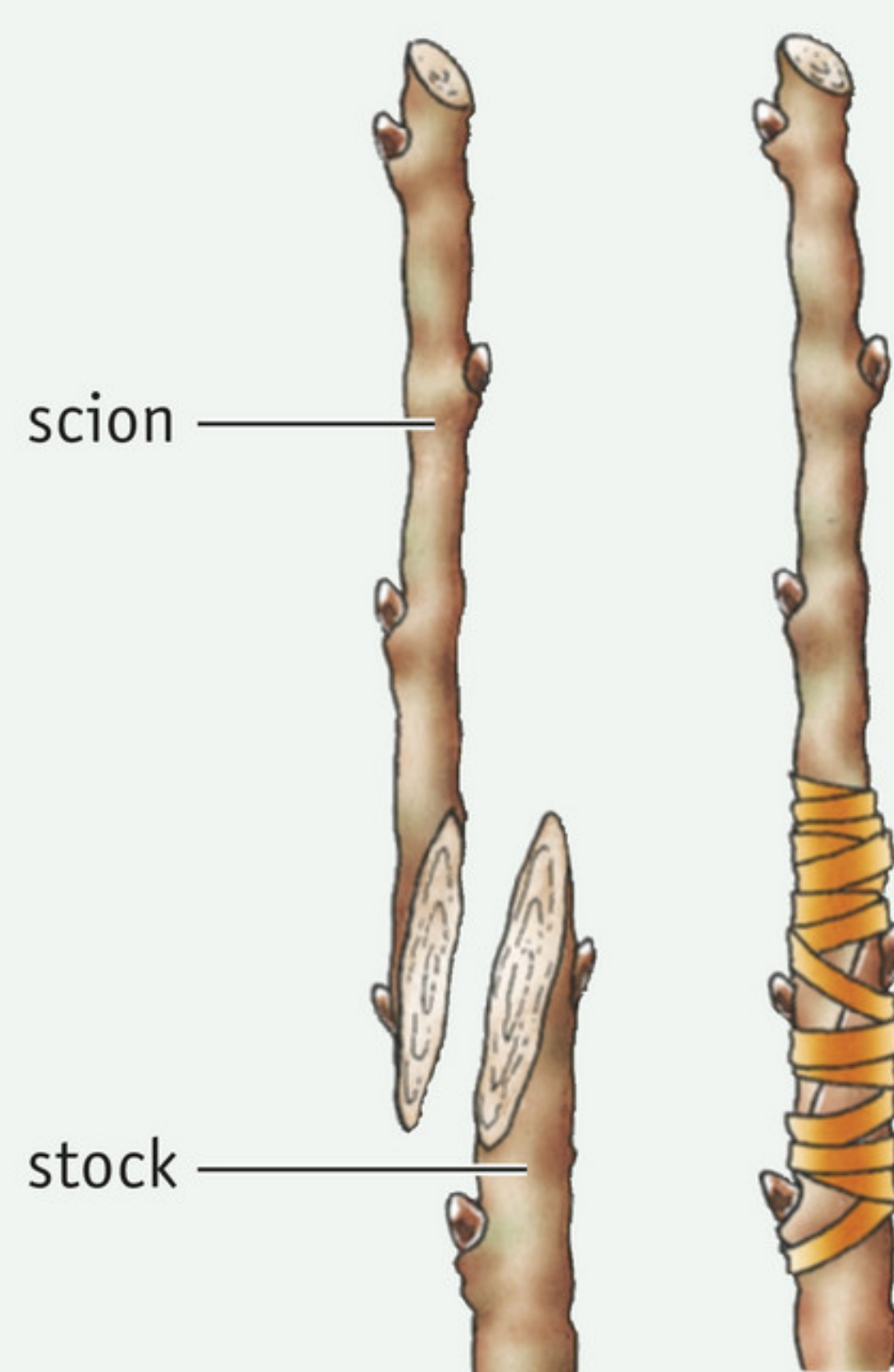
A tree grower grafts a twig from a sweet cherry tree onto the stock of a sour cherry tree. The grafted twig grows nicely on the root stock. Later, the grafted branch produces flowers and then cherries.

- 7 What kind of cherries will grow on this grafted branch: sweet cherries, sour cherries, or a blend of the two? Explain your answer.
8 Is grafting a form of sexual reproduction or asexual reproduction?

▼ Fig. 65

Growing apple trees

Apple trees are mostly produced by grafting. This method lets you attempt to combine the best features of two varieties. You might for instance first grow a number of saplings (young trees) of a variety that only produces small apples that are susceptible to diseases. Once those trees are big enough, they are cut off at an angle. The tree that has been cut off like this is called the root stock (see the illustration). Branches are then cut off an apple tree of a particular variety, with large, sweet apples such as a Golden Delicious. This graft is called a scion. One or more scions are placed on the root stock. A special type of tape is used to hold the grafted twig onto the stock. The stock and the grafts then grow to become a single tree. The apples that grow on this tree are the same as the apples from the tree that was used for the grafts. Grafting is done in a similar way for other fruit trees.



EXTRA OBJECTIVE 8

Answer the following multiple choice questions.

- 1 Figure 66 shows schematic drawings of three flowers.

Which of these flowers is (or are) unisexual?

- A Only flower 1.
- B Only flower 2.
- C Only flower 3.
- D Flowers 2 and 3.

- 2 In which of the flowers in figure 66 can pollen from a stamen pollinate the same flower?

- A Only in flower 1.
- B Only in flower 2.
- C Only in flowers 1 and 2.
- D In flowers 1, 2 and 3.

- 3 Which of the flowers in figure 66 can produce fruits with seeds?

- A Only flower 1.
- B Flowers 1 and 2.
- C Flowers 1 and 3.
- D Flowers 2 and 3.

▼ Fig. 66

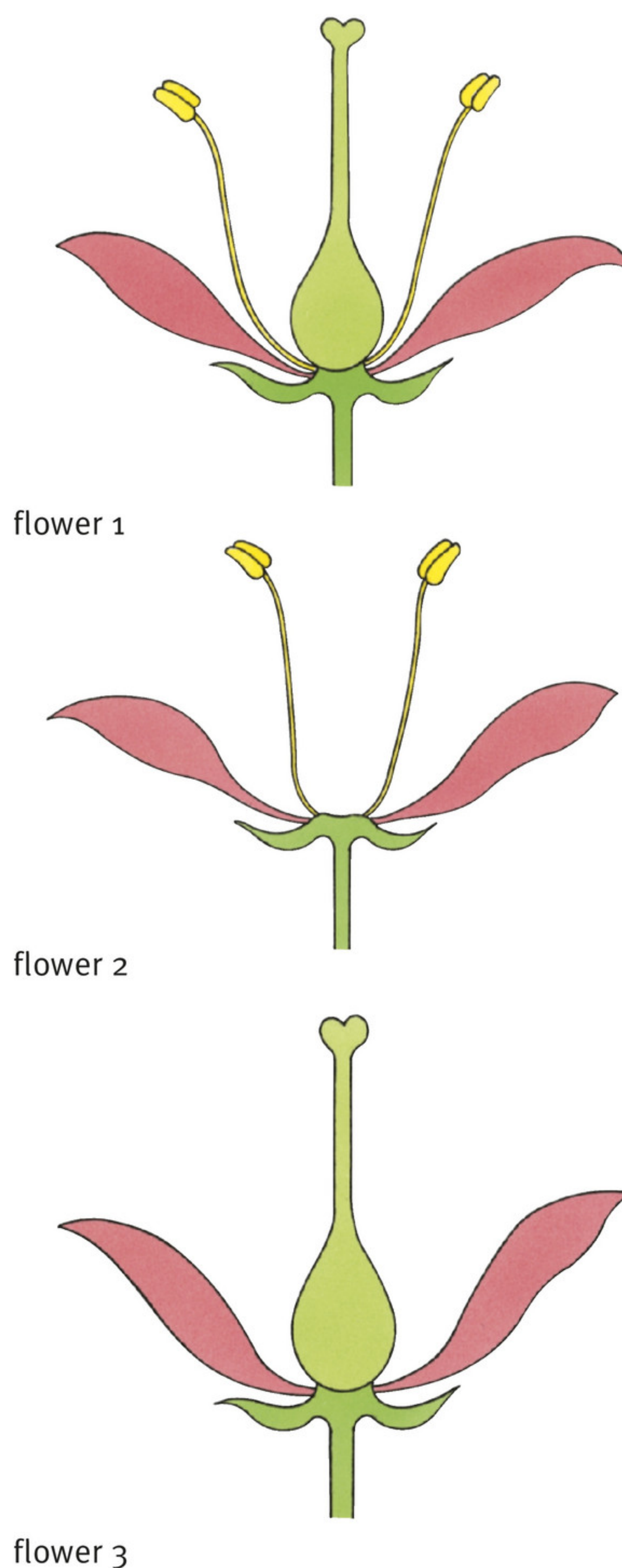


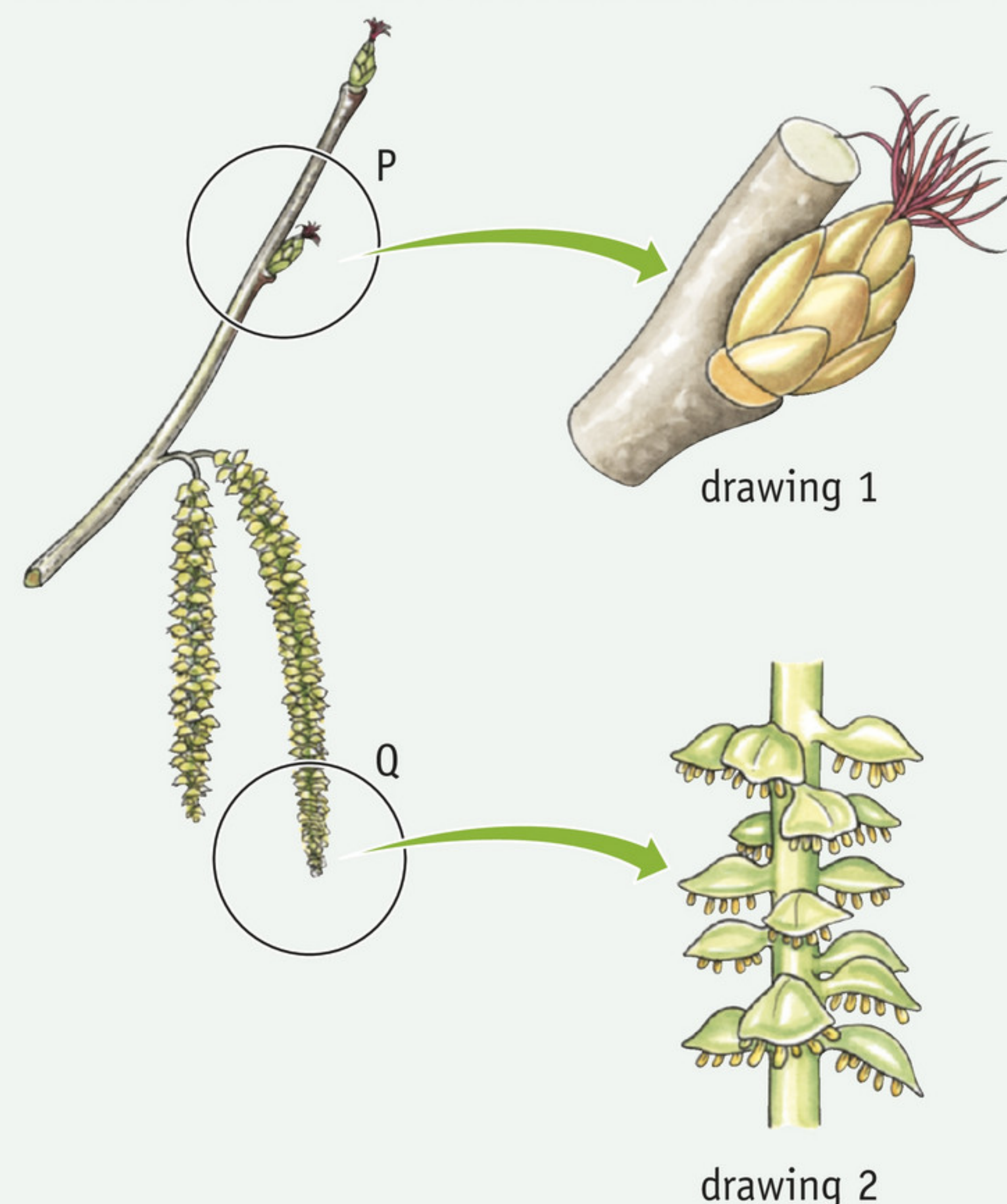
Figure 67 is an article about the hazel tree. Questions 4 to 6 are about the article.

- 4 Will a hazel generally be cross-pollinated or self-pollinated? And will the pollination be done by insects or by the wind?
- A Cross-pollination by the wind.
 - B Cross-pollination by insects.
 - C Self-pollination by the wind.
 - D Self-pollination by insects.
- 5 Is a hazel a monoecious plant or a dioecious plant? And are the flowers of a hazel unisexual or bisexual?
- A The hazel is a monoecious plant with unisexual flowers.
 - B The hazel is a monoecious plant with bisexual flowers.
 - C The hazel is a dioecious plant with unisexual flowers.
 - D The hazel is a dioecious plant with bisexual flowers.
- 6 After pollination and fertilisation, which type of flower can grow to produce hazel nuts?
- A Only type P.
 - B Only type Q.
 - C Both type P and type Q.
 - D Neither type.

▼ Fig. 67

Hazel

A hazel is a shrub that blossoms in early spring. Two types of flowers (catkins) grow on the branches. These are labelled P and Q in the drawing. You can see the long catkins (Q) of the hazel as early as February. Drawing 2 shows part of catkin Q, magnified. If you tap this kind of catkin, a lot of dry powder comes out of it. The other type of flower (P) is shown magnified in drawing 1. The fruits of the hazel shrub are called hazelnuts. A single hazel does not normally produce any hazelnuts if there are no other hazel plants nearby.



You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three topics. You can do the exercises for them in your workbook.

1 Less familiar fruits

Some fruits are not so well known. In this extension, you will be solving a puzzle about them and you will taste some fruits that you may not know.

WB EXERCISES 1 AND 2, PAGE 109

▼ Fig. 68



durian



cactus fig (prickly pear)



carambola (starfruit)



physalis (lantern fruit)



passion fruit



pomegranate



pitahaya



plantain



grapefruit



sharon fruit (kaki fruit)



papaya



lychee

2 Studying a flower

▼ Fig. 69 Wild flowers.



In the basics, you studied the flower of a deadnettle. In this extension, you will examine a flower of your choice. You have to make drawings of it. You will find some plants (or parts of plants) with flowers in the classroom. Pick one out. Or you could even bring in a flowering plant yourself.

WB EXERCISE 1, PAGE 111

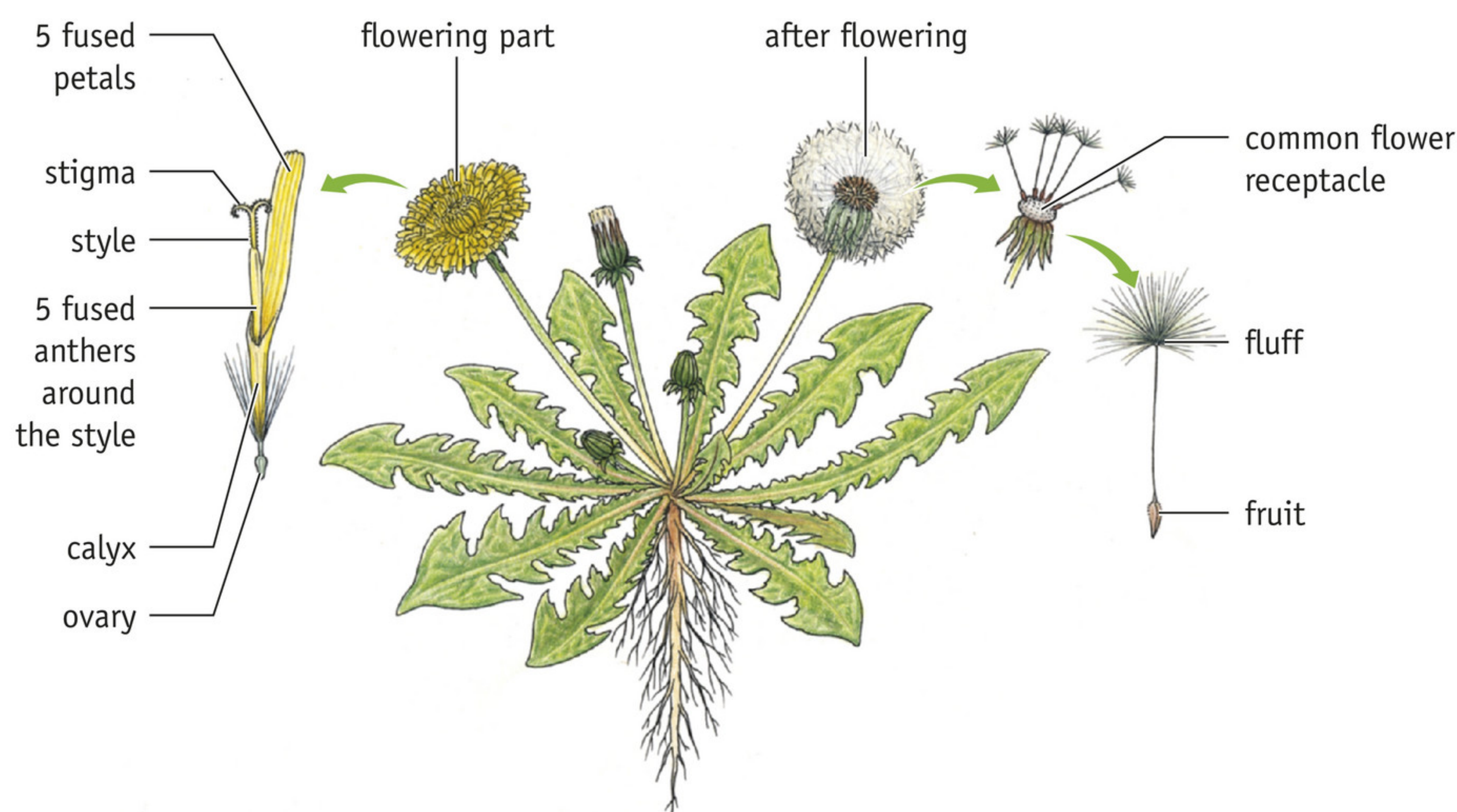
3 Compound flowers

In this extension, you will be examining a dandelion. Most people think that the yellow part of a dandelion is a single flower. But it isn't. In this extension you will find out that a dandelion is really made up of a large number of small flowers. You have to make drawings and answer questions.

The dandelion belongs to a large family of plants that we call compound flowers or composite flowers. What seems at first glance to be a single flower is in fact made up of a large number of little flowers. A single flower of a dandelion is called a ray floret. Each ray floret consists of a number of fused petals, a carpel and stamens that have fused with the style of the carpel (see figure 70). The flowers are attached to a common flower receptacle.

WB EXERCISES 1 AND 2, PAGE 113

► Fig. 70



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